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Kawaguchi et al.

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(54) **CUTTING APPARATUS AND CUTTING CONTROL PROGRAM THEREFOR**

(71) Applicant: **BROTHER KOGYO KABUSHIKI KAISHA**, Nagoya-shi, Aichhi-ken (JP)

(72) Inventors: **Yasuhiko Kawaguchi**, Nagoya (JP); **Yoshinori Nakamura**, Toyohashi (JP); **Masahiko Nagai**, Nagoya (JP); **Tomoyasu Niizeki**, Ichinomiya (JP); **Katsuhisa Hasegawa**, Kasugai (JP)

(73) Assignee: **BROTHER KOGYO KABUSHIKI KAISHA**, Nagoya-shi (JP)

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Mar. 30, 2011 (JP) 2011-075579

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B26D 7/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B26D 5/005*** (2013.01); ***B26D 7/025*** (2013.01); ***B26D 7/04*** (2013.01); ***B26F 1/3813*** (2013.01);
(Continued)

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CPC B26D 5/00; B26D 5/005; B26D 7/025; B26D 7/04; B26F 1/3813; Y10T 83/5669; Y10T 83/7573
See application file for complete search history.

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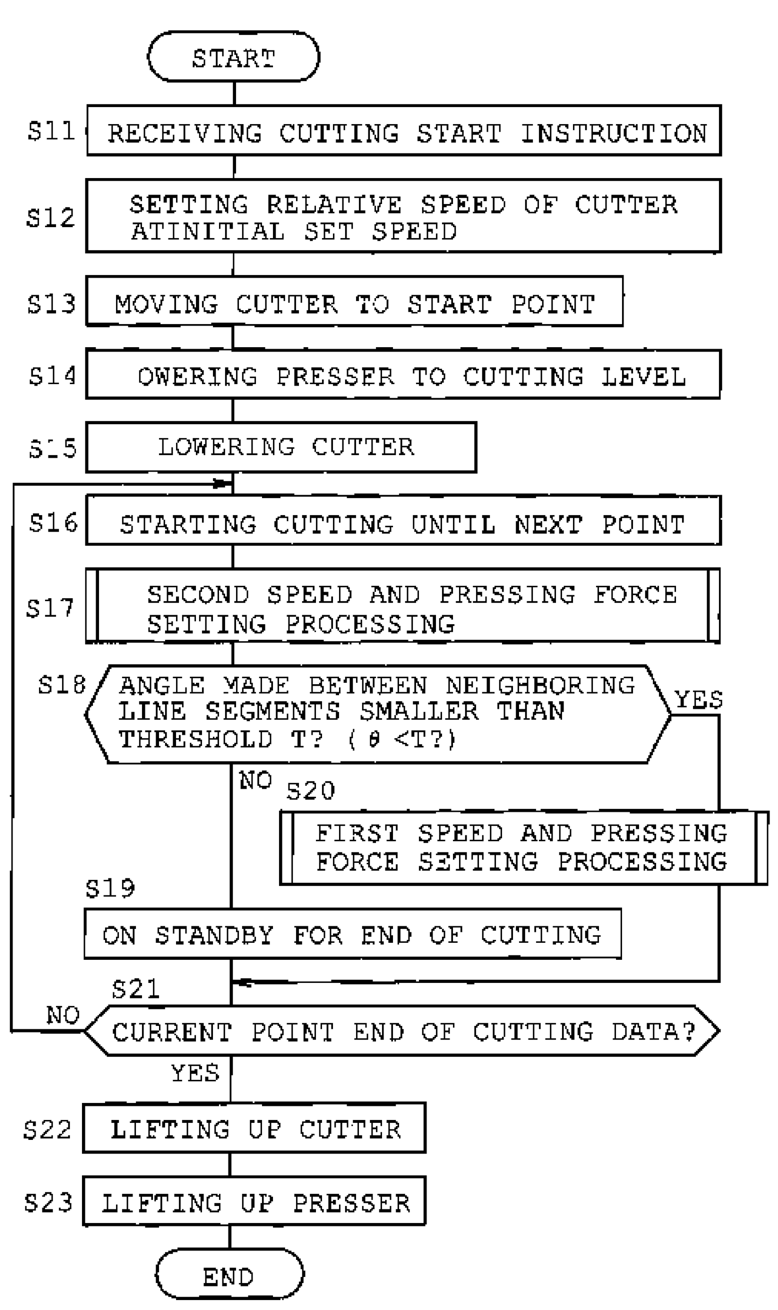
Primary Examiner — Stephen Choi
(74) *Attorney, Agent, or Firm* — K&L Gates LLP

(57) **ABSTRACT**

A cutting apparatus includes a holding member disposed at a position opposed to a cutting blade and having an adhesive layer removably holding an object, a pressing unit pressing the object held by the holding member and having a contact portion brought into contact with the object, a region specifying unit specifying a region where an adhesive retention of the adhesive layer is insufficient along a cutting line of the object cut by the blade, and a control unit controlling the pressing unit so that when the object is cut by moving the blade and the holding member holding the object relative to each other, at least either an amount of pressing or a pressing force of the contact portion is changed between a case where the region specified by the region specifying unit is cut and a case where any part other than the specified region is cut.

2 Claims, 16 Drawing Sheets



(51) **Int. Cl.**
B26D 7/04 (2006.01)
B26F 1/38 (2006.01)

(52) **U.S. Cl.**
CPC *B26D 5/00* (2013.01); *Y10T 83/5669* (2015.04); *Y10T 83/7573* (2015.04)

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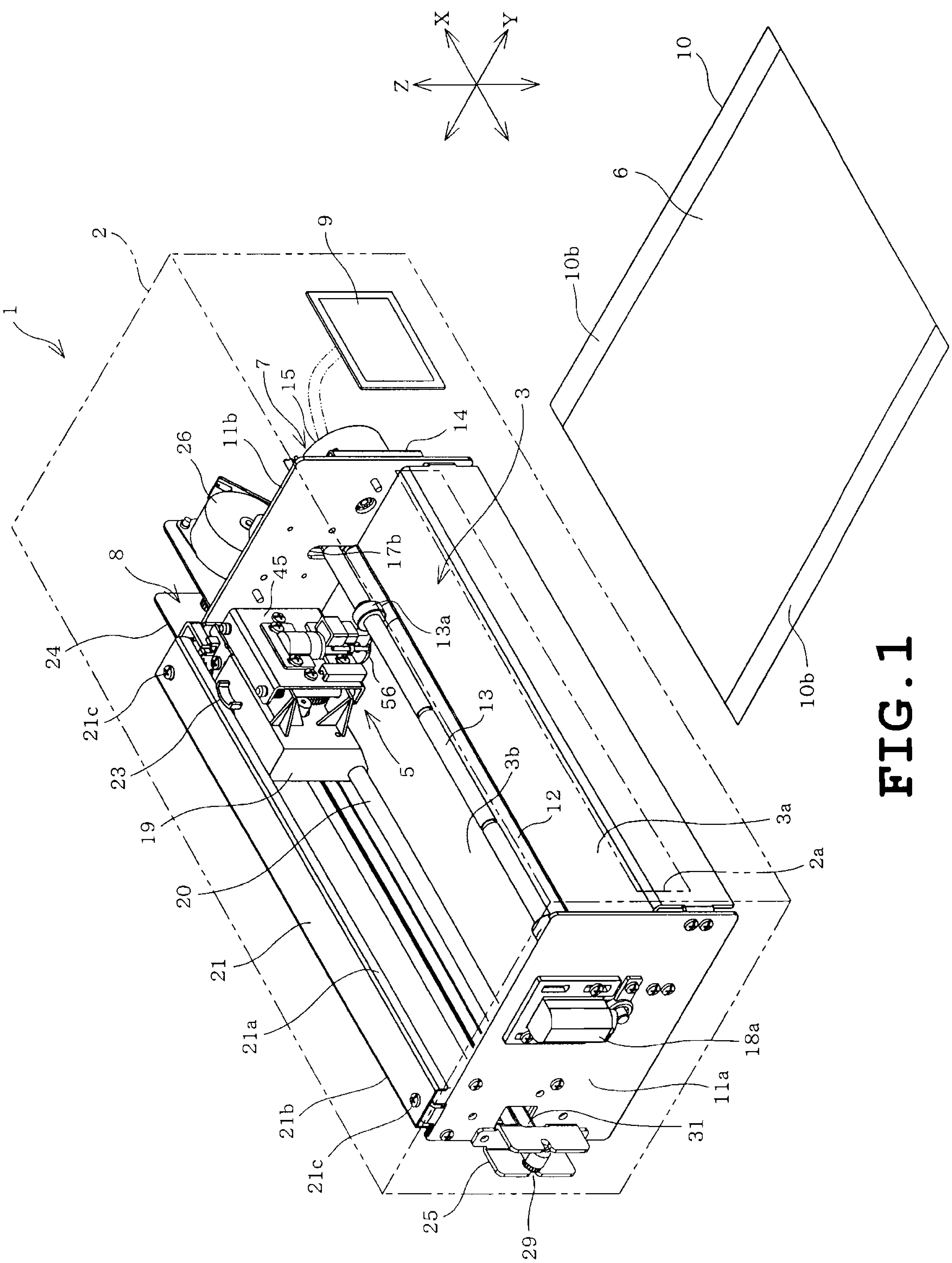
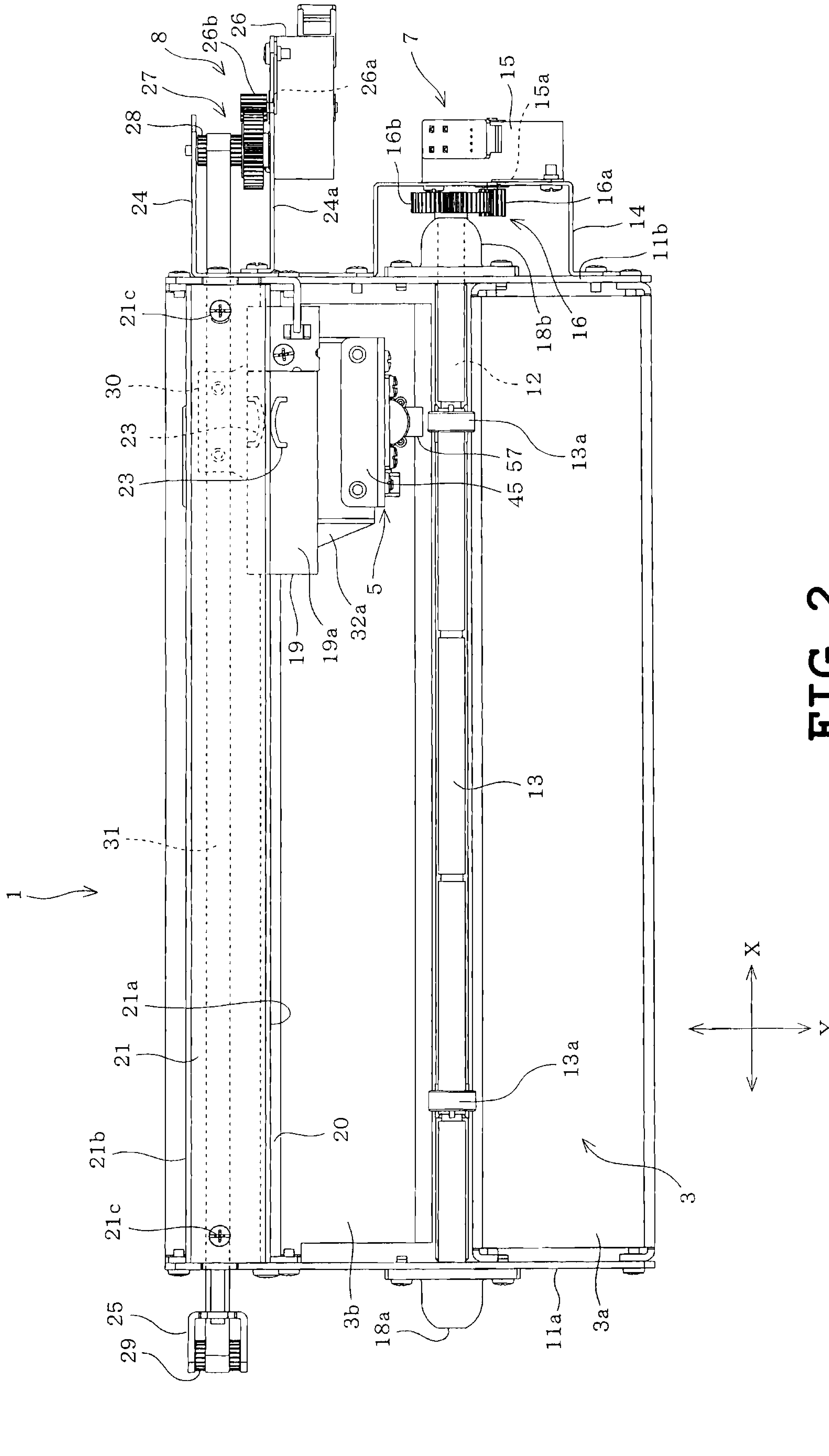

X
Y
Z
1
2
2a
3
3a
3b
5
6
7
8
9
10
10b
10b
11a
11b
12
13
13a
14
15
17b
18a
19
20
21
21a
21b
21c
21c
23
24
25
26
29
31
45
56

FIG. 1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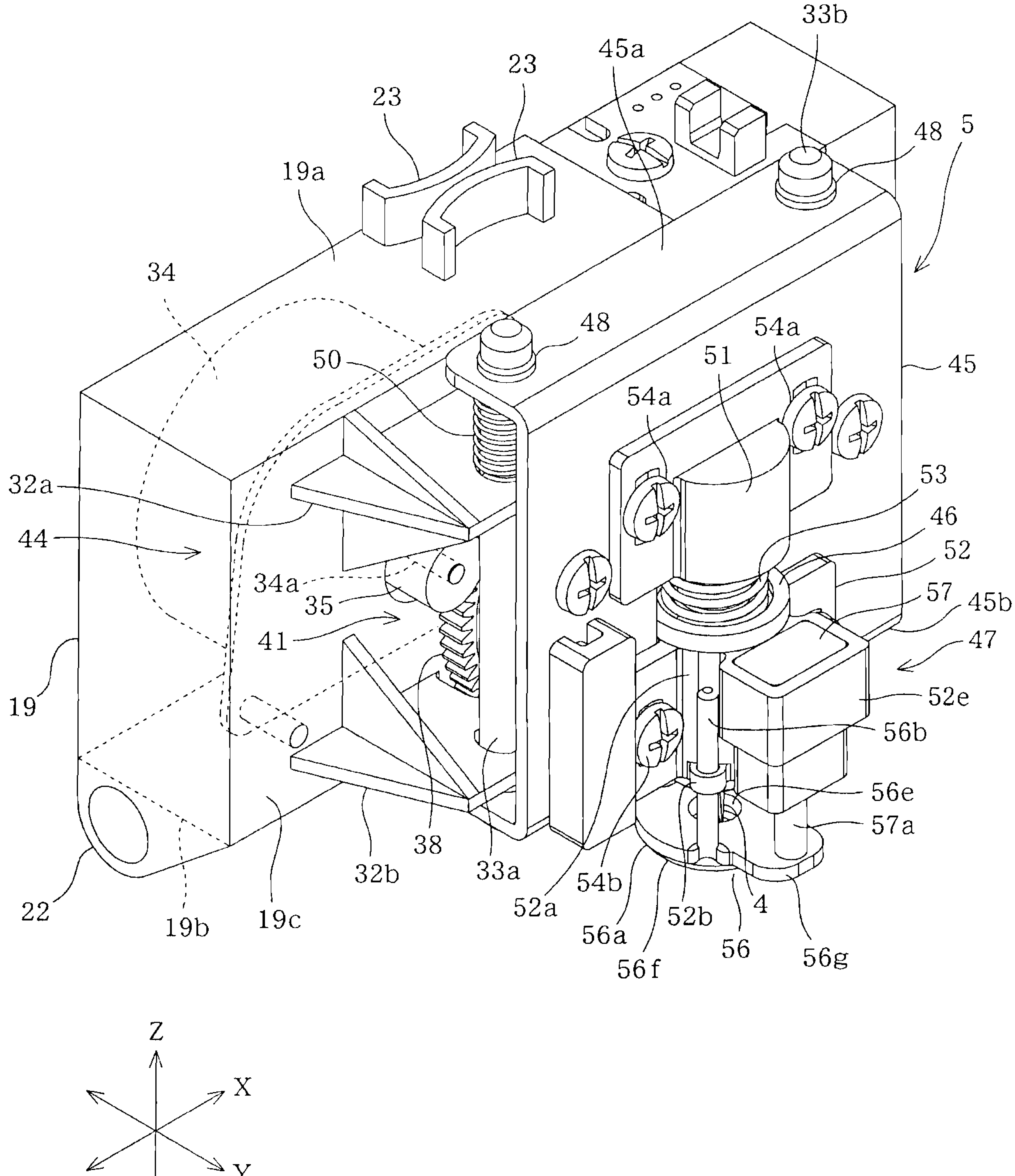
26a
27
28
24
24a
7
15
15a
16b
16a
14
11b
16
18b
21c
30
23
23
12
13a
57
45
5
32a
19a
19
31
1
13
21a
21
21b
20
13a
X
Y
3
21c
3b
25
29
18a
11a
3a

FIG. 2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23
48
5
19a
34
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54a
50
51
45
54a
32a
53
46
44
52
34a
57
45b
35
47
41
52e
19
56b
56e
57a
38
33a
54b
32b
4
52a
22
19b
19c
52b
56a
56
56g
56f
Z
X
Y

FIG. 3

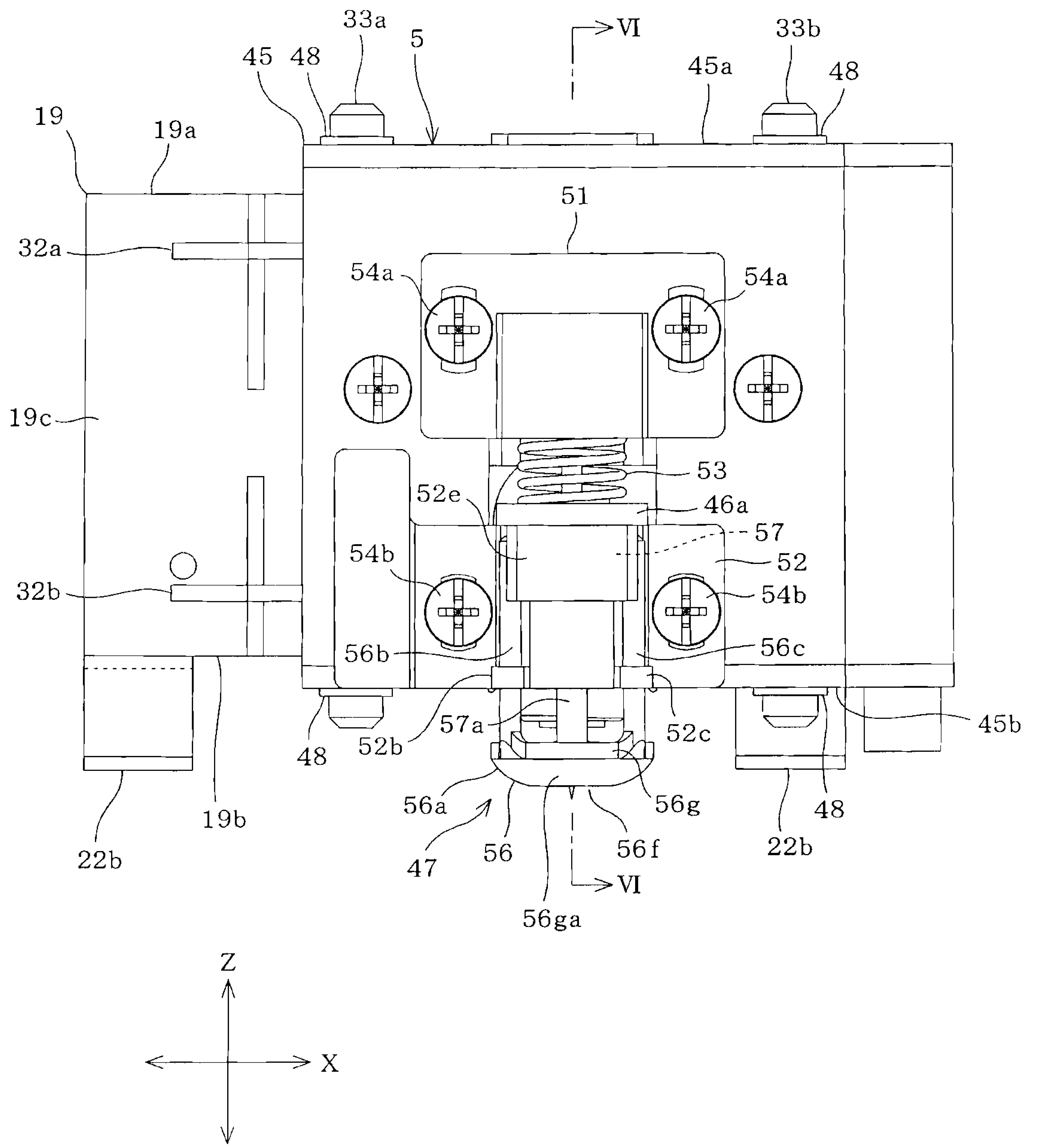
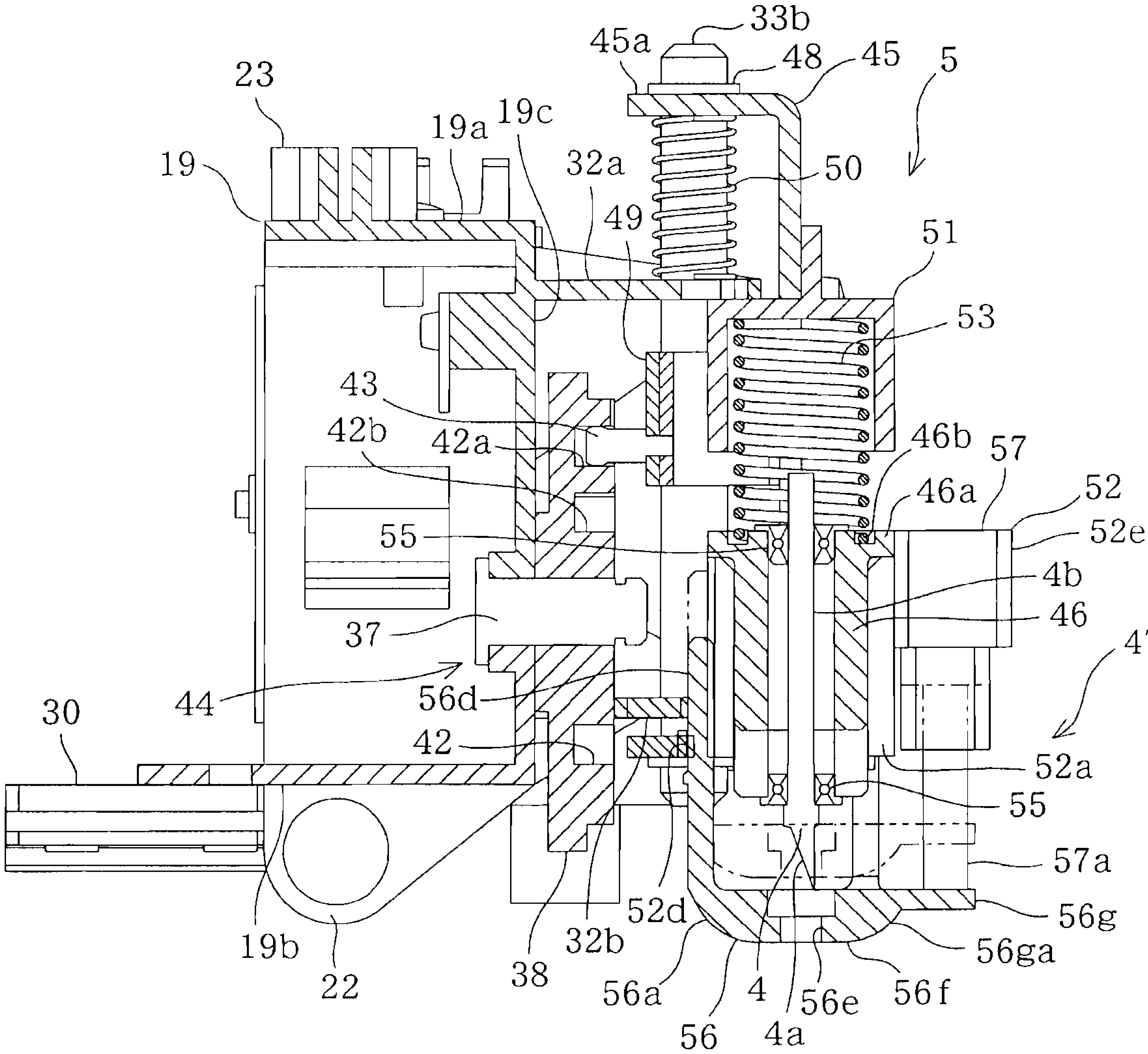

33a
5
VI
33b
45
48
45a
48
19
19a
51
32a
54a
54a
19c
53
52e
46a
57
54b
52
32b
54b
56b
56c
57a
52c
45b
48
52b
48
56a
56g
48
19b
22b
56
56f
22b
47
VI
56ga
Z
X

FIG. 4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45
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19c
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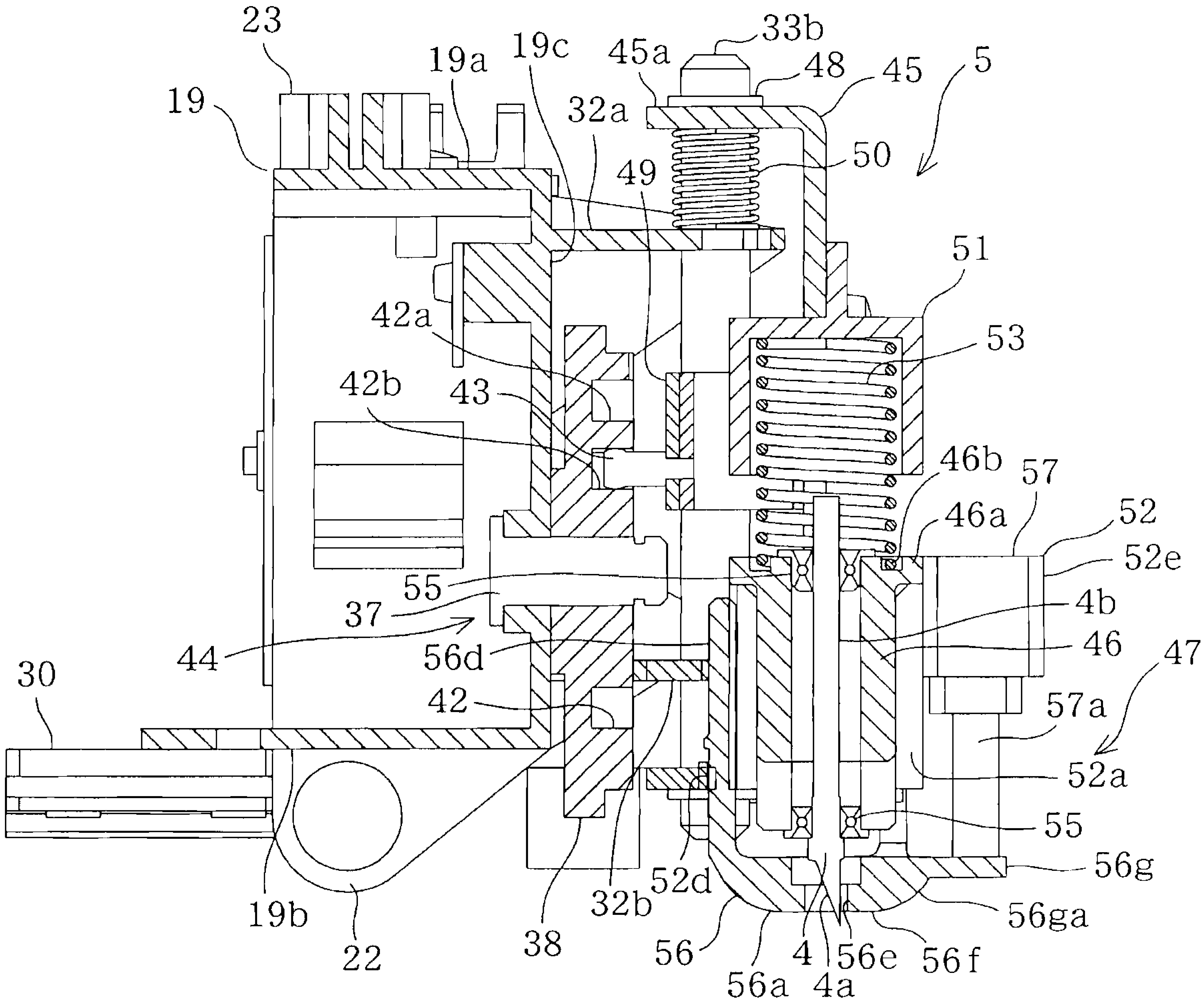
32a
50
49
51
53
43
42b
42a
46b
57
46a
52
52e
55
4b
46
37
47
44
56d
30
42
52a
55
57a
56g
52d
56ga
19b
22
38
32b
56a
4
56e
56f
56
4a

FIG. 5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19c
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32a
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49
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42a
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42b
43
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52
46a
52e
55
4b
37
46
44
56d
47
30
42
57a
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56f
56a
4a

FIG. 6

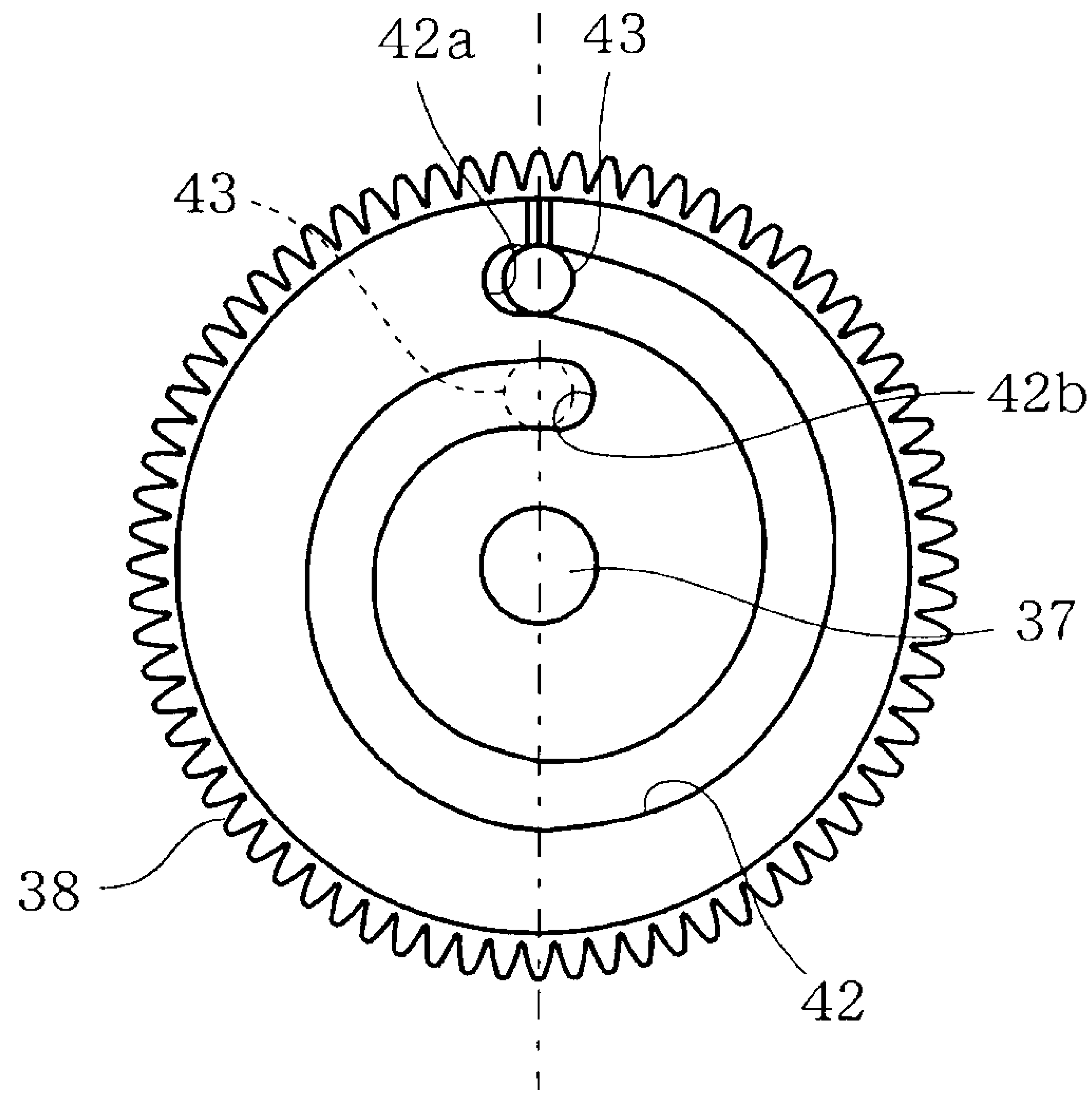


FIG. 7

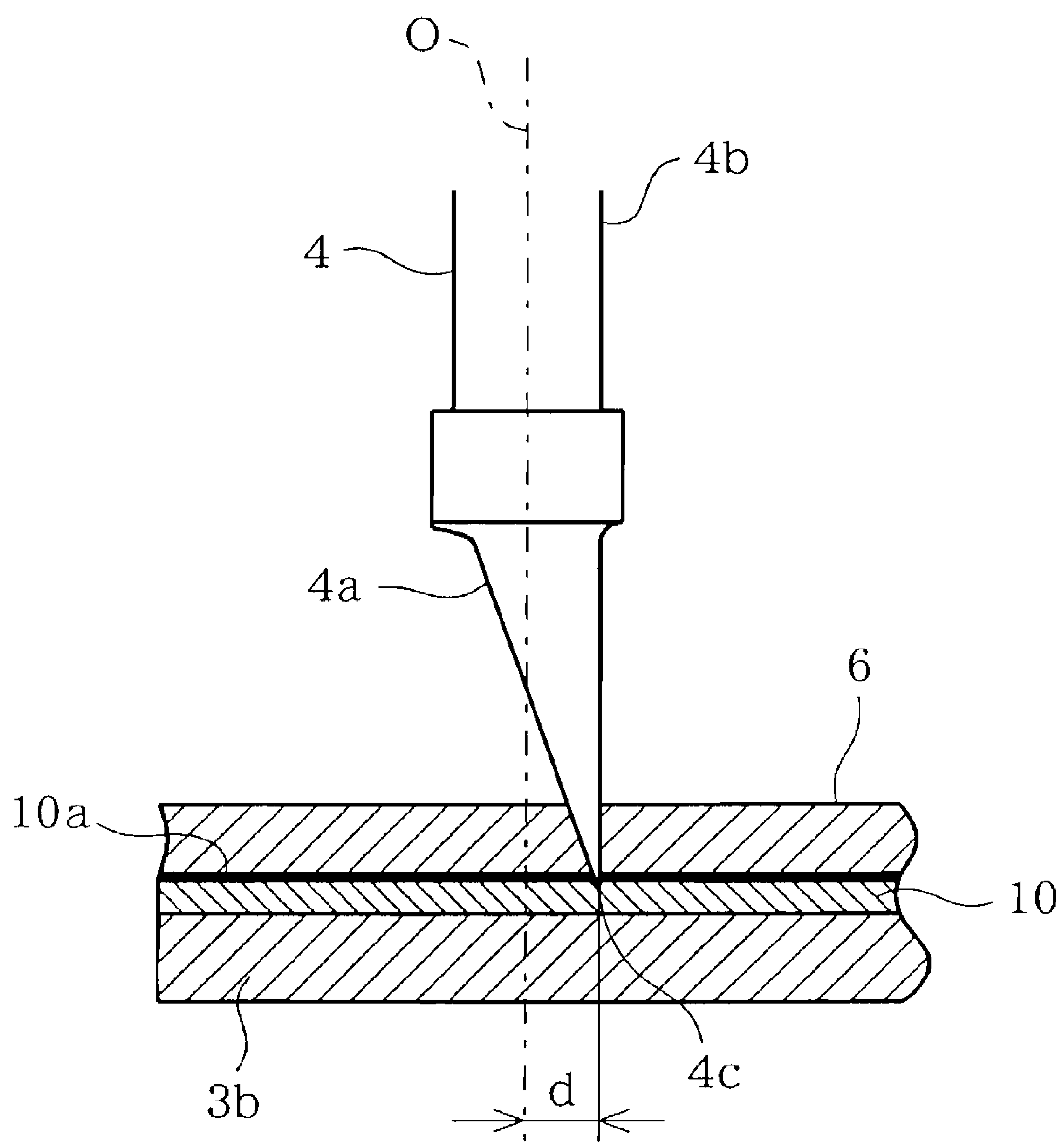
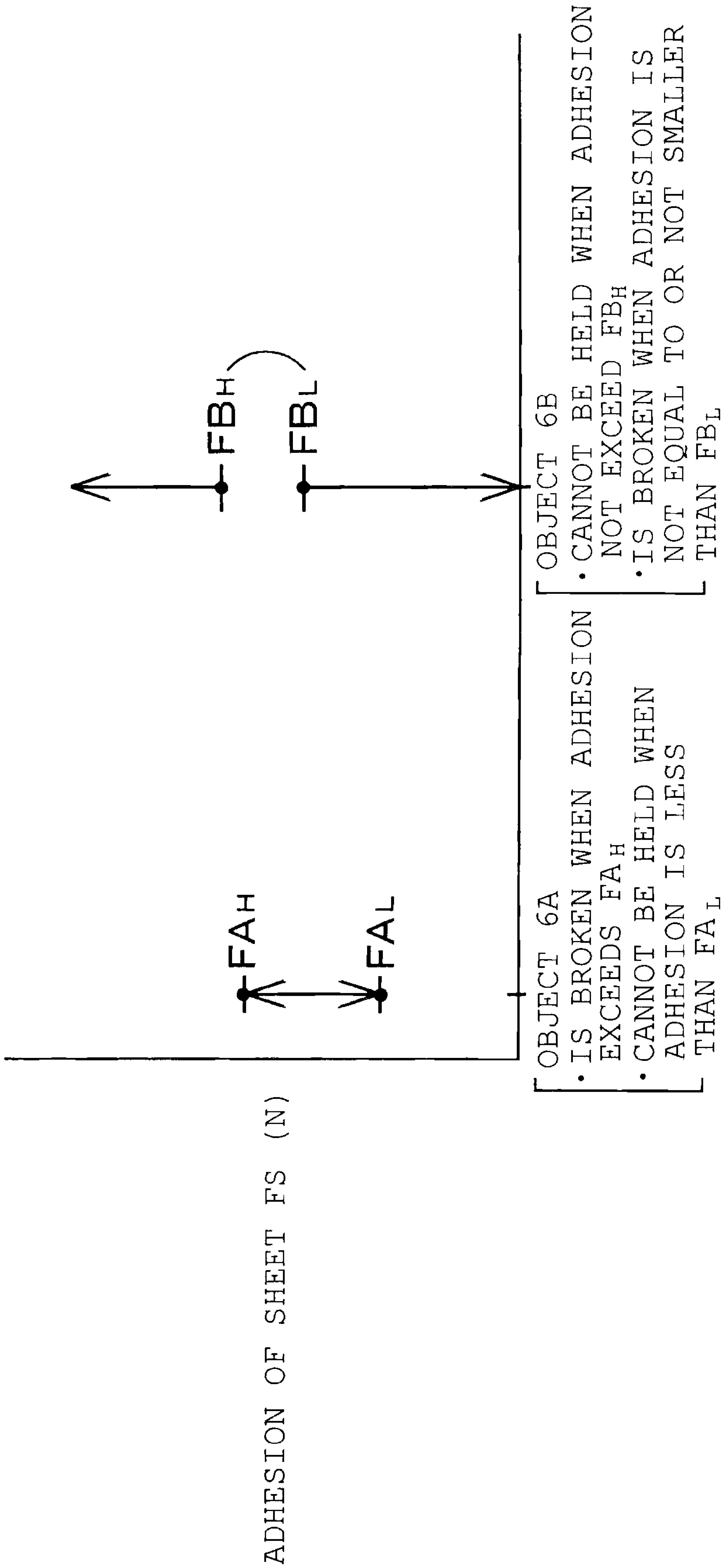


FIG. 8



ADHESION OF SHEET FS (N)
FA_H
FA_L
FB_H
FB_L
OBJECT 6A
· IS BROKEN WHEN ADHESION EXCEEDS FA_H
· CANNOT BE HELD WHEN ADHESION IS LESS THAN FA_L
OBJECT 6B
· CANNOT BE HELD WHEN ADHESION NOT EXCEED FB_H
· IS BROKEN WHEN ADHESION IS NOT EQUAL TO OR NOT SMALLER THAN FB_L

FIG. 9

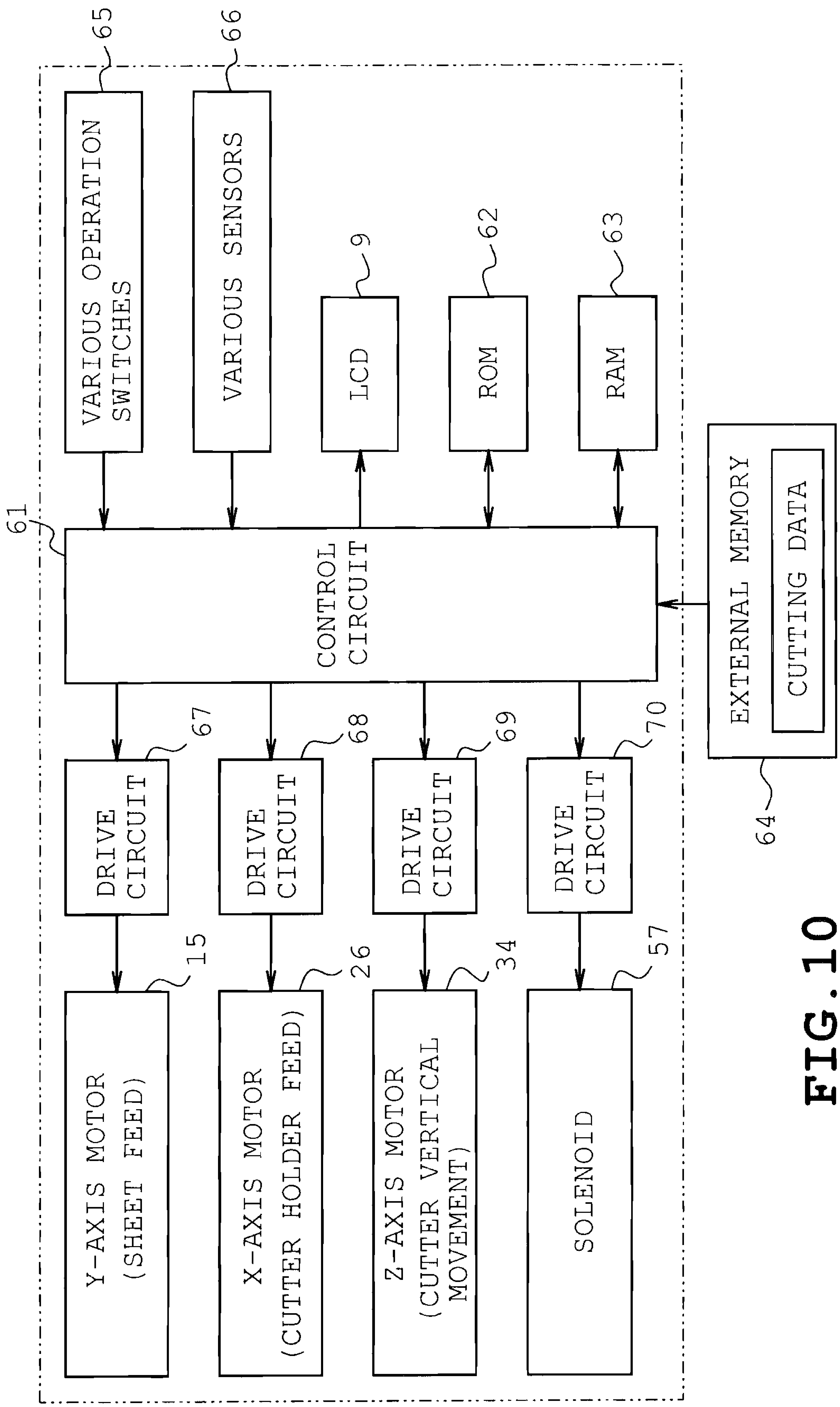
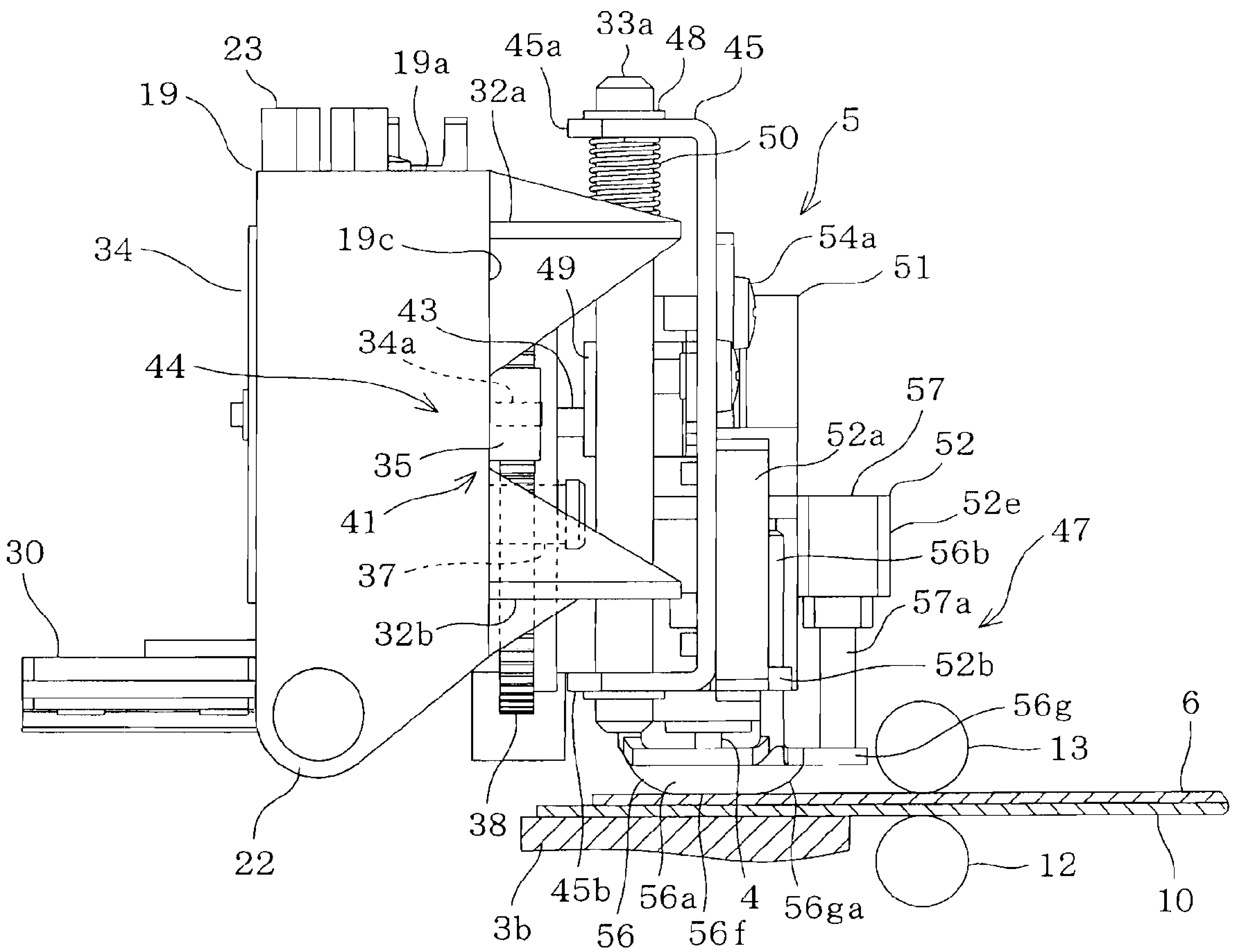

VARIOUS OPERATION SWITCHES
65
VARIOUS SENSORS
66
LCD
9
ROM
62
RAM
63
61
CONTROL CIRCUIT
EXTERNAL MEMORY
CUTTING DATA
64
DRIVE CIRCUIT
67
DRIVE CIRCUIT
68
DRIVE CIRCUIT
69
DRIVE CIRCUIT
70
Y-AXIS MOTOR (SHEET FEED)
15
X-AXIS MOTOR (CUTTER HOLDER FEED)
26
Z-AXIS MOTOR (CUTTER VERTICAL MOVEMENT)
34
SOLENOID
57

FIG. 10



23
19
19a
32a
45a
33a
48
45
50
5
34
19c
49
54a
51
43
34a
44
57
52a
52
35
52e
41
47
56b
30
37
57a
32b
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56g
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13
38
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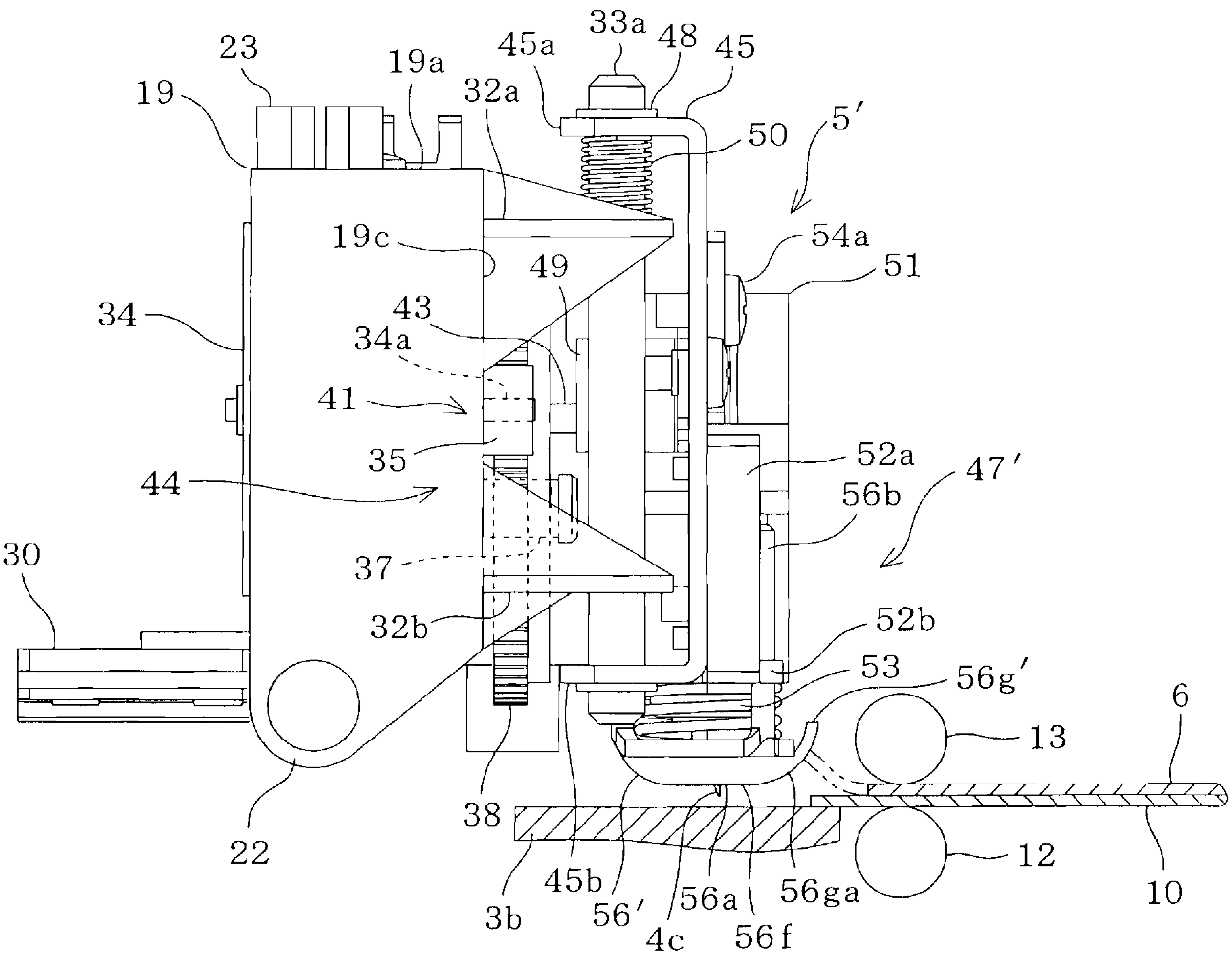
12
3b
45b
56a
4
56ga
10
56
56f

FIG.11



23
19a
45a
33a
48
45
19
32a
50
5′
19c
54a
49
51
34
43
34a
41
35
52a
44
47′
56b
30
37
32b
52b
53
56g′
6
13
38
12
22
45b
56ga
3b
56′
56a
10
4c
56f

FIG. 12

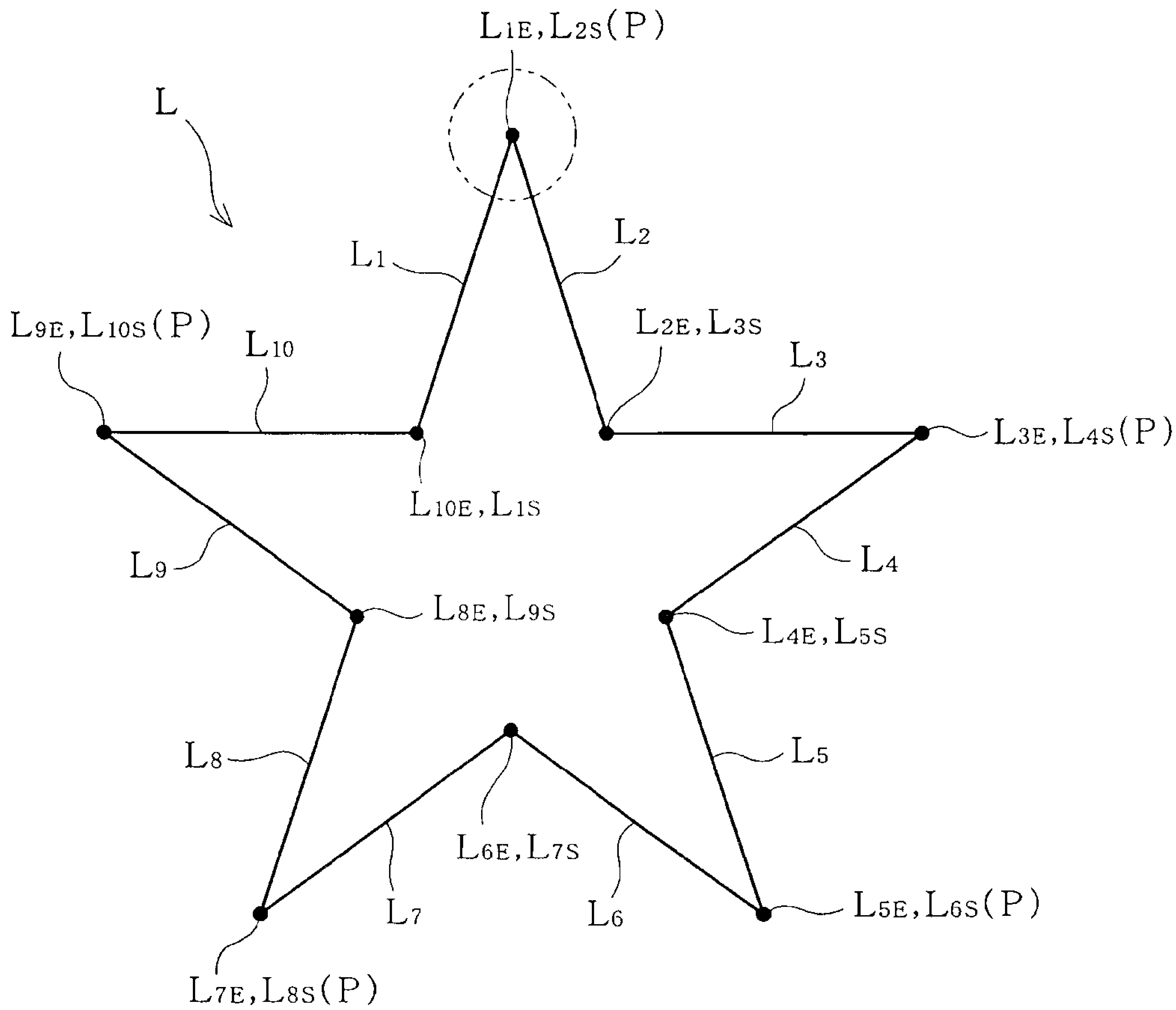


FIG.13A

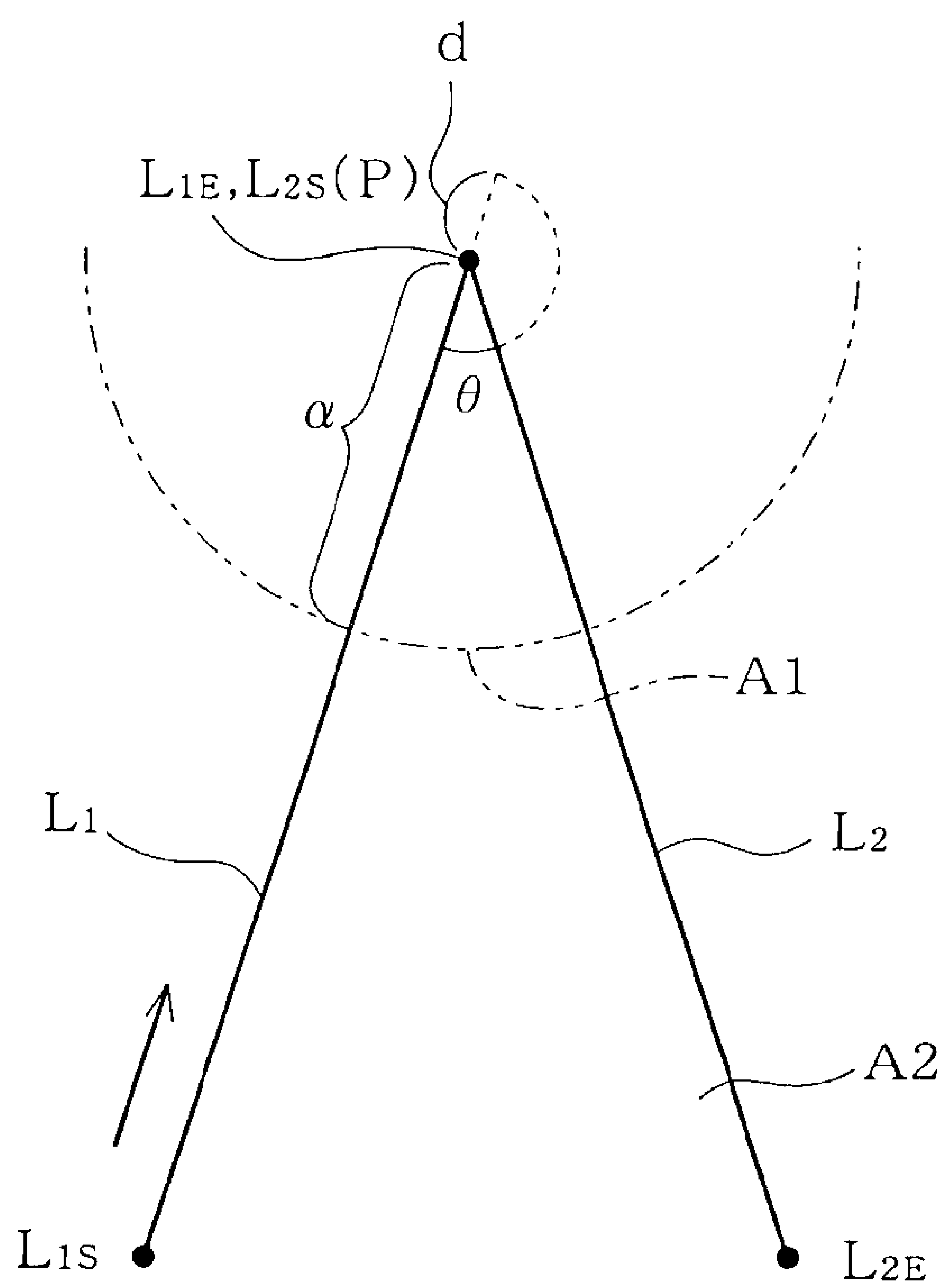


FIG.13B

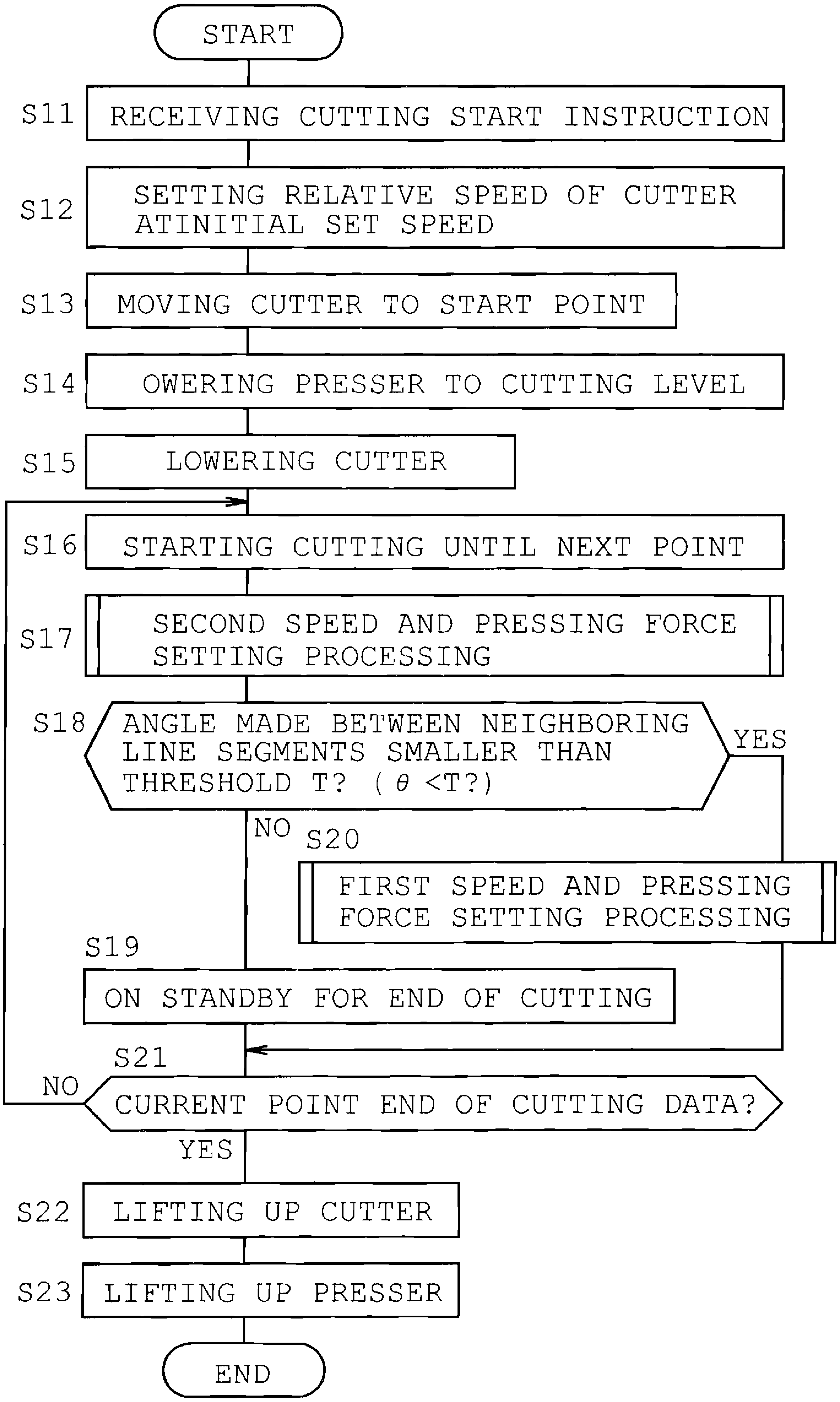

START
S11
RECEIVING CUTTING START INSTRUCTION
S12
SETTING RELATIVE SPEED OF CUTTER ATINITIAL SET SPEED
S13
MOVING CUTTER TO START POINT
S14
OWERING PRESSER TO CUTTING LEVEL
S15
LOWERING CUTTER
S16
STARTING CUTTING UNTIL NEXT POINT
S17
SECOND SPEED AND PRESSING FORCE SETTING PROCESSING
S18
ANGLE MADE BETWEEN NEIGHBORING LINE SEGMENTS SMALLER THAN THRESHOLD T? (θ <T?)
YES
NO
S20
FIRST SPEED AND PRESSING FORCE SETTING PROCESSING
S19
ON STANDBY FOR END OF CUTTING
S21
NO
CURRENT POINT END OF CUTTING DATA?
YES
S22
LIFTING UP CUTTER
S23
LIFTING UP PRESSER
END

FIG. 14

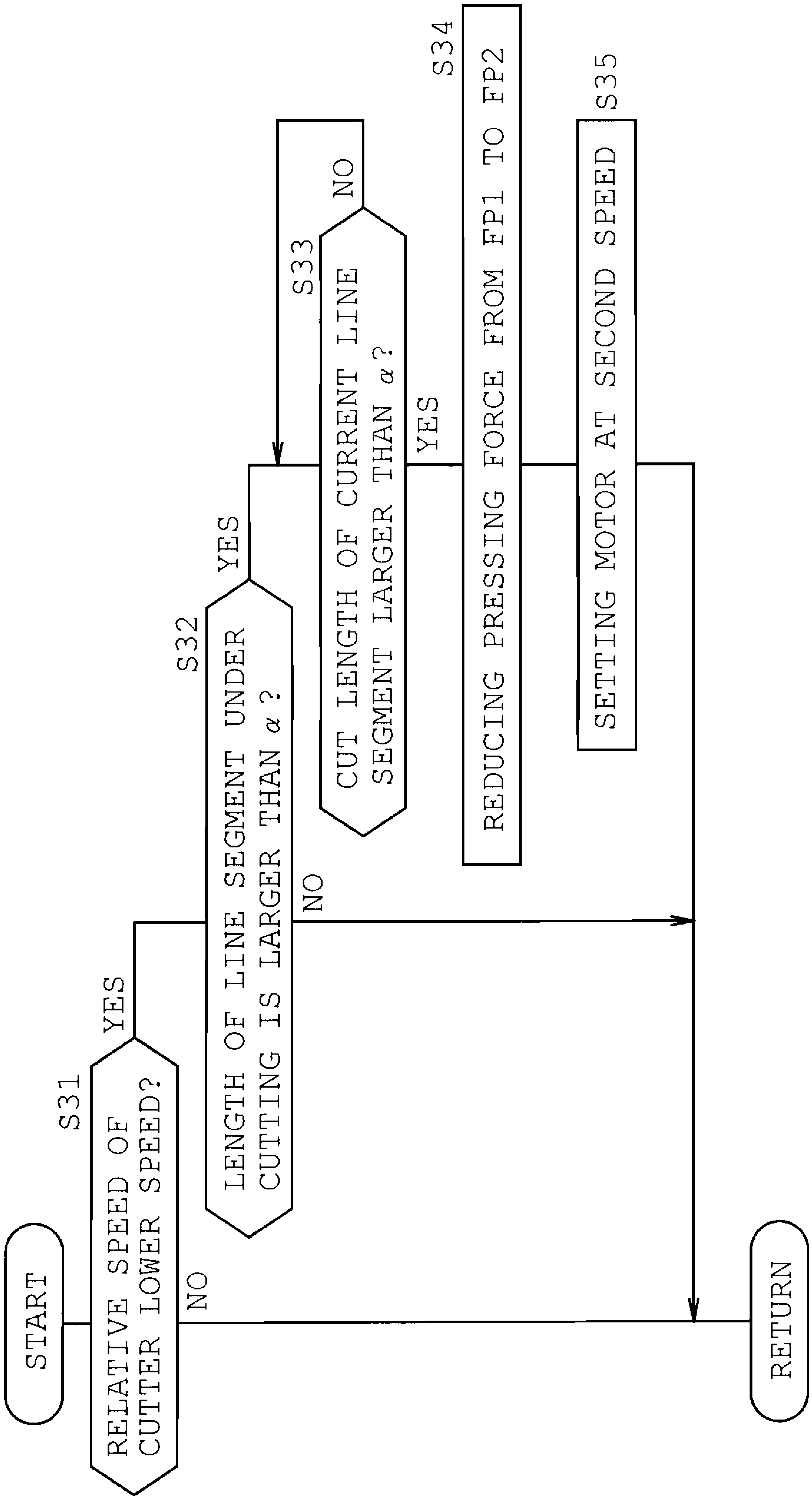

START
S31
RELATIVE SPEED OF CUTTER LOWER SPEED?
NO
YES
S32
LENGTH OF LINE SEGMENT UNDER CUTTING IS LARGER THAN α?
NO
YES
S33
CUT LENGTH OF CURRENT LINE SEGMENT LARGER THAN α?
NO
YES
S34
REDUCING PRESSING FORCE FROM FP1 TO FP2
S35
SETTING MOTOR AT SECOND SPEED
RETURN

FIG.15

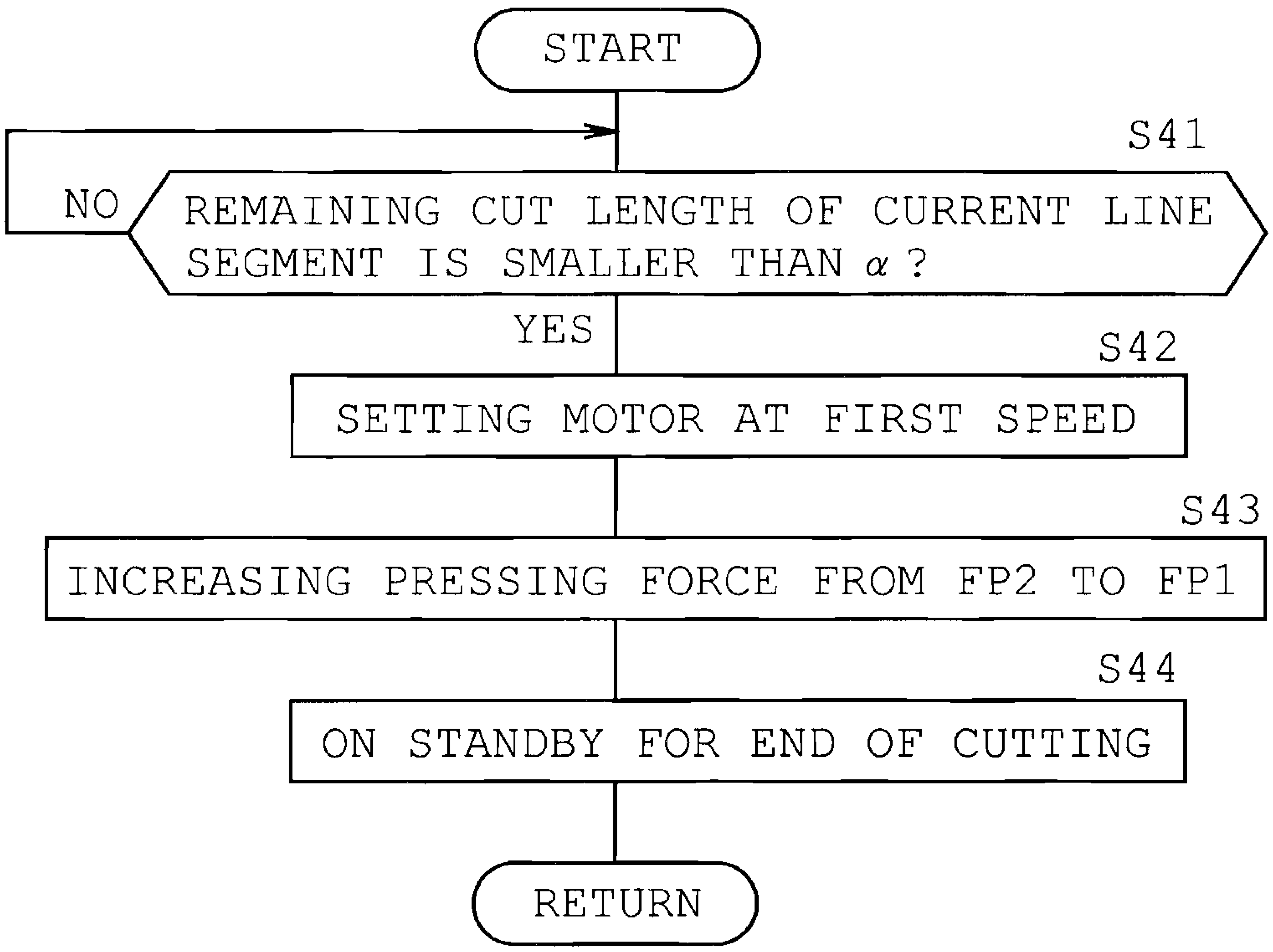

START
S41
NO
REMAINING CUT LENGTH OF CURRENT LINE SEGMENT IS SMALLER THAN α ?
YES
S42
SETTING MOTOR AT FIRST SPEED
S43
INCREASING PRESSING FORCE FROM FP2 TO FP1
S44
ON STANDBY FOR END OF CUTTING
RETURN

FIG.16

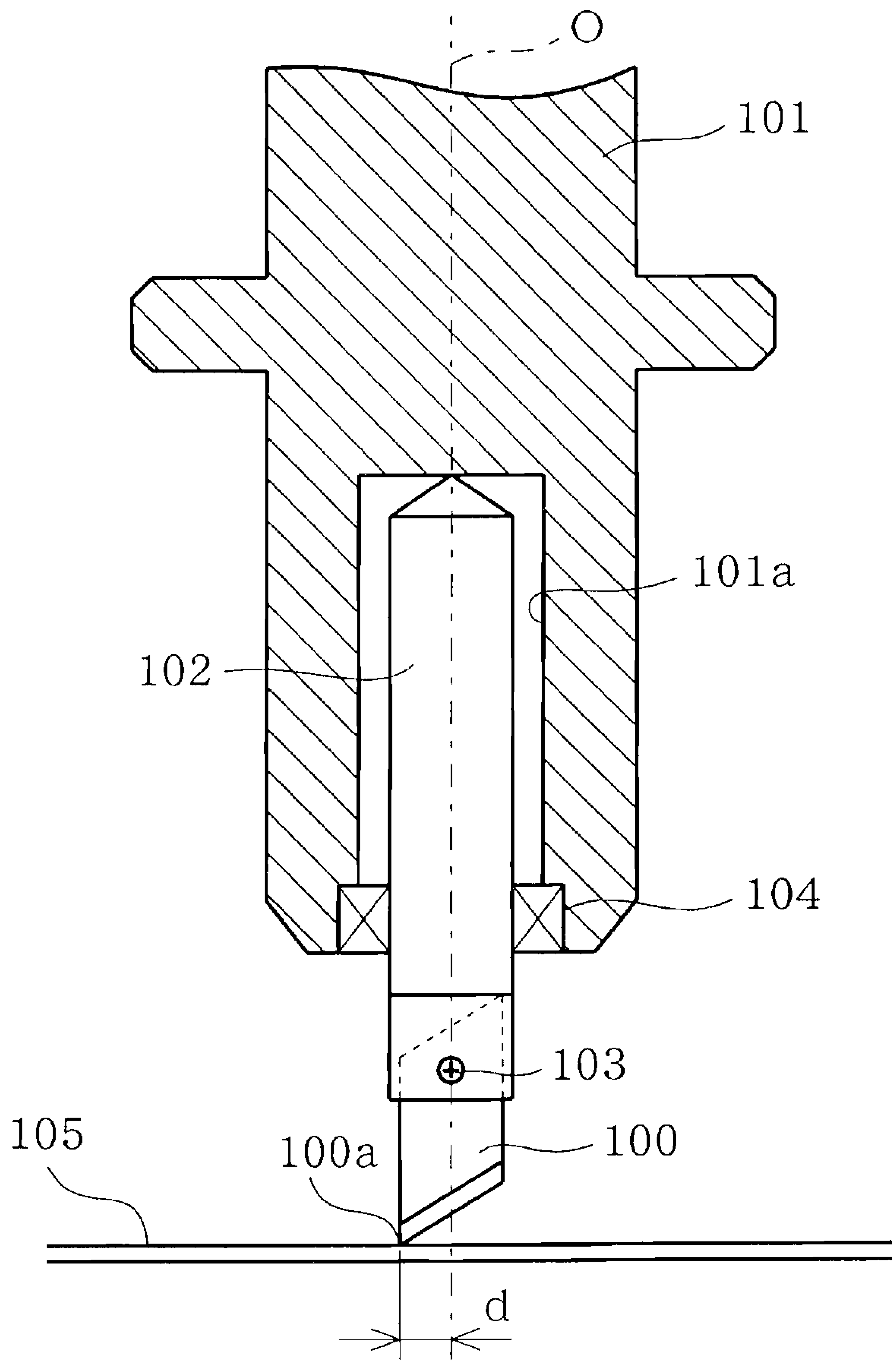


FIG. 17 RELATED ART

CUTTING APPARATUS AND CUTTING CONTROL PROGRAM THEREFOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional of U.S. patent application Ser. No. 13/421,950, filed on Mar. 16, 2012, which is based upon and claims the benefit of priority from the prior Japanese Patent Application Nos. 2011-075577 and 2011-075579 both filed on Mar. 30, 2011, the entire contents of which are incorporated herein by reference.

BACKGROUND

1. Technical Field

The present disclosure relates to a cutting apparatus in which a cutting blade and an object to be cut are moved relative to each other so that the object is cut by the cutting blade and a storage medium which is computer-readable and stores a control program on which the object is cut into a desirable shape.

2. Related Art

There has conventionally been known a cutting plotter which automatically cuts a sheet-like object to be cut, such as paper or resin sheet. The cutting plotter includes a drive mechanism having rollers which hold the object from the vertical direction so that the object is moved in a first direction. The drive mechanism also includes a carriage having a cutting blade which is moved in a second direction perpendicular to the first direction, whereby the object is cut.

FIG. **17** schematically illustrates an ordinary cutter (a cutting blade) **100** and a cutter holder **101** both provided in the conventional cutting plotter. As shown, the cutter **100** is fixed to a lower end of a bar-like cutter mount **102** by a screw **103**. The cutter mount **102** is supported by a bearing **104** attached to a recess **101***a* formed in the lower end of the cutter holder **101**, whereby the cutter mount **102** is rotatable about an axis line O. Furthermore, the cutter **100** has a blade edge **100***a* which is offset by a predetermined distance d relative to the axis line O. Accordingly, when the cutter **100** and a sheet **105** are moved relative to each other so that the sheet **105** is cut by the cutter **100**, the blade edge **100***a* of the cutter **100** is subjected to a resistive force (reactive force) from the sheet **105** such that the cutter mount **102** is rotated about the axis line O. More specifically, the direction of the blade edge **100***a* of the cutter **100** is automatically changed according to a moving direction in which the cutter **100** and the sheet **105** are moved relative to each other.

Additionally, one of the above-described type cutting plotters is provided in which a sheet such as paper is pressed from upward by a biasing plate thereby to be prevented from floating. In this cutting plotter, the sheet around the cutter can be pressed by the aforementioned biasing plate so as not to float. However, when a part of desired shape has been cut out of the sheet, a driving force of the drive mechanism is not transferred to the cut-out portion of the sheet. Accordingly, the sheet cannot be moved correctly.

In view of the above-described problem, an improved cutting plotter is proposed in which a sheet such as paper is affixed to a sheet-like member (corresponding to a holding member) having an adhesive layer on a surface thereof. In this case, the sheet can strongly be held when the adhesion of the adhesive layer is increased. However, it becomes difficult to remove the sheet from the sheet-like member when the adhesion of the adhesive layer is increased. On the other hand, when the adhesion of the adhesive layer is

reduced, the sheet cannot strongly be supported although the sheet can easily be removed from sheet-like member. In this case, there is a possibility that the sheet would be displaced relative to the sheet-like member such that the sheet could not be cut accurately. More specifically, the conventional cutting plotters having strong and weak adhesions have respective defects, both of which defects have been desired to be improved.

SUMMARY

Therefore, an object of the disclosure is to provide a cutting apparatus in which the object can reliably be held by the holding member and can accurately be cut and the object can easily be removed from the holding member.

The present disclosure provides a cutting apparatus in which a cutting blade and an object to be cut are moved relative to each other based on cutting data, so that the object is cut by the cutting blade. The cutting apparatus includes a holding member which is disposed at a position opposed to the cutting blade and has an adhesive layer removably holding the object; a pressing unit which presses the object held by the holding member, the pressing unit having a contact portion brought into contact with the object; a region specifying unit which specifies a region where an adhesive retention of the adhesive layer is insufficient along a cutting line of the object cut by the cutting blade based on the cutting data; and a control unit which controls the pressing unit so that when the object is cut by moving the cutting blade and the holding member holding the object relative to each other, at least either an amount of pressing or a pressing force of the contact portion against the object is changed between a case where the region specified by the region specifying unit is cut and a case where any part of the object other than the specified region is cut.

The disclosure also provides a medium which is non-transitory and computer-readable and stores a program that is incorporated in a cutting apparatus including a holding member which is disposed at a position opposed to a cutting blade and has an adhesive layer removably holding an object to be cut and a pressing unit which presses the object held by the holding member and has a contact portion contacting the object. The object is cut by the cutting blade by moving the cutting blade and the holding member holding the object relative to each other. The program causes a control device of the cutting apparatus to execute instructions comprising specifying a region where an adhesive retention of the adhesive layer is insufficient along a cutting line of the object cut by the cutting blade based on the cutting data and controlling the pressing unit so that when the object is cut by moving the cutting blade and the holding member holding the object relative to each other, at least either an amount of pressing or a pressing force of the contact portion against the object is changed between a case where the region specified by the region specifying unit is cut and a case where any part of the object other than the specified region is cut.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a perspective view of the cutting apparatus according to a first embodiment, showing an inner structure thereof;

FIG. **2** is a plan view of the cutting apparatus;

FIG. **3** is a perspective view of a cutter holder;

FIG. **4** is a front view of the cutter holder, showing the state where a cutter has been descended;

FIG. **5** is a sectional view of the cutter holder, showing the case where the cuter has been ascended;

FIG. **6** is a sectional view taken along lines VI-VI in FIG. **4**;

FIG. **7** is an enlarged front view of a gear;

FIG. **8** is an enlarged view of the vicinity of a distal end of the cutter during the cutting;

FIG. **9** is a schematic graph explaining the relationship between an adhesion of the holding member (an adhesive layer) and a type of the object;

FIG. **10** is a block diagram showing an electrical arrangement of the cutting apparatus;

FIG. **11** is a side view of a cutter holder and the neighbor thereof during the cutting;

FIG. **12** is a view similar to FIG. **11**, showing a second embodiment;

FIGS. **13**A and **13**B are a view of an example of cutting line of the object and an enlarged view of a partial corner of the cutting line in FIG. **13**A, respectively;

FIG. **14** is a flowchart showing an entire processing flow relating to depressing the object by a pressing unit;

FIG. **15** is a flowchart showing a flow of second speed setting processing;

FIG. **16** is a flowchart showing a flow of first speed setting processing; and

FIG. **17** is an enlarged sectional view of a distal end of the cutter holder generally used with a conventional cutting plotter.

DETAILED DESCRIPTION

First Embodiment

A first embodiment will be described with reference to FIGS. **1** to **11**. Referring to FIG. **1**, a cutting apparatus **1** includes a body cover **2** as a housing, a platen **3** provided in the body cover **2** and a cutter holder **5** also provided in the body cover **2**. The cutting apparatus **1** also includes first and second moving units **7** and **8** for moving a cutter **4** (see FIG. **5**) of the cutter holder **5** and an object **6** to be cut, relative to each other. The body cover **2** is formed into the shape of a horizontally long rectangular box and has a front formed with a horizontally long opening **2***a* which is provided for setting a holding sheet **10** holding the object **6**. In the following description, the side where the user who operates the cutting apparatus **1** stands will be referred to as “front” and the opposite side will be referred to as “back.” The front-back direction thereof will be referred to as “Y direction.” The right-left direction perpendicular to the Y direction will be referred to as “X direction.”

On a right part of the body cover **2** is provided a liquid crystal display (LCD) **9** which serves as a display unit displaying messages and the like necessary for the user. A plurality of operation switches **65** (see FIG. **10**) is also provided on the right part of the body cover **2**. The platen **3** includes a pair of front and rear plate members **3***a* and **3***b* and has an upper surface which is configured into an X-Y plane serving as a horizontal plane. The platen **3** is set so that the holding sheet **10** holding the object **6** is placed thereon. The holding sheet **10** is received by the platen **3** when the object **6** is cut. The holding sheet **10** has an upper surface with an adhesive layer **10***a* (see FIG. **8**) formed by applying an adhesive agent to a part thereof except for right and left edges **10***b*. The object **6** is affixed to the adhesive layer **10***a* thereby to be held.

The first moving unit **7** moves the holding sheet **10** on the upper surface side of the platen **3** in the Y direction (a first direction). More specifically, a driving roller **12** and a pinch roller **13** are provided on right and left sidewalls **11***b* and **11***a* so as to be located between plate members **3***a* and **3***b*. The driving roller **12** and the pinch roller **13** extend in the X direction and are rotatably supported on the sidewalls **11***b* and **11***a*. The driving roller **12** and the pinch roller **13** are disposed so as to be parallel to the X-Y plane and so as to be vertically arranged. The driving roller **12** is located lower than the pinch roller **13**. A first crank-shaped mounting frame **14** is provided on the right sidewall **11***b* so as to be located on the right of the driving roller **12** as shown in FIG. **2**. A Y-axis motor **15** is fixed to an outer surface of the mounting frame **14**. The Y-axis motor **15** comprises a stepping motor, for example and has a rotating shaft **15***a* extending through the first mounting frame **14** and further has a distal end provided with a gear **16***a*. The driving roller **12** has a right end to which is secured another gear **16***b* which is brought into mesh engagement with the gear **16***a*. These gears **16***a* and **16***b* constitute a first reduction gear mechanism **16**. The pinch roller **13** is guided by guide grooves **17***b* formed in the right and left sidewalls **11***b* and **11***a* so as to be movable upward and downward. Only the right guide groove **17***b* is shown in FIG. **1**. Two spring accommodating members **18***a* and **18***b* are mounted on the right and left sidewalls **11***b* and **11***a* in order to cover the guide groove **17***b* from the outside respectively. The pinch roller **13** is biased downward by compression coil springs (not shown) accommodated in the spring accommodating portions **18***a* and **18***b* respectively. The pinch roller **13** is provided with pressing portions **13***a* which are brought into contact with a left edge **10***b* and a right edge **10***c* of the holding sheet **10**, thereby pressing the edges **10***b* and **10***c*, respectively. Each pressing portion **13***a* has a slightly larger outer diameter than the other portion of the pinch roller **13**.

The driving roller **12** and the pinch roller **13** press the holding sheet **10** from below and from above by the urging force of the compression coil springs thereby to hold the holding sheet **10** therebetween (see FIG. **11**). Upon drive of the Y-axis motor **15**, normal or reverse rotation of the Y-axis motor **15** is transmitted via the first reduction gear mechanism **16** to the driving roller **12**, whereby the holding sheet **10** is moved backward or forward together with the object **6**. The first moving unit **7** is thus constituted by the driving roller **12**, the pinch roller **13**, the Y-axis motor **15**, the first reduction gear mechanism **16**, the compression coil springs and the like.

The second moving unit **8** moves a carriage **19** supporting the cutter holder **5** in the X direction (a second direction). The second moving unit **8** will be described in more detail. A guide shaft **20** and a guide frame **21** both extending in the right-left direction are provided between the right and left sidewalls **11***b* and **11***a* so as to be located at the rear end of the cutting apparatus **1**, as shown in FIGS. **1** and **2**. The guide shaft **20** is disposed in parallel with the driving roller **12** and the pinch roller **13**. The guide shaft **20** located right above the platen **3** extends through a lower part of the carriage **19** (a through hole **22** as will be described later). The guide frame **21** has a front edge **21***a* and a rear edge **21***b* both folded downward such that the guide frame **21** has a generally C-shaped section. The front edge **21***a* is disposed in parallel with the guide shaft **20**. The guide frame **21** is adapted to guide an upper part (guided members **23** as will be described later) of the carriage **19** by the front edge **21***a*. The guide frame **21** is fixed to upper ends of the sidewalls **11***a* and **11***b* by screws **21***c* respectively.

A second mounting frame **24** is mounted on the right sidewall **11***b* in the rear of the cutting apparatus **1**, and an auxiliary frame **25** is mounted on the left sidewall **11***a* in the rear of the cutting apparatus **1**, as shown in FIG. **2**. An X-axis motor **26** and a second reduction gear mechanism **27** are provided on the second mounting frame **24**. The X-axis motor **26** comprises a stepping motor, for example and is fixed to a front of a front mounting piece **24***a*. The X-axis motor **26** includes a rotating shaft **26***a* which extends through the mounting piece **24***a* and has a distal end provided with a gear **26***b* which is brought into mesh engagement with the second reduction gear mechanism **27**. A pulley **28** is rotatably mounted on the second reduction gear mechanism **27**, and another pulley **29** is rotatably mounted on the left auxiliary frame **25** as viewed in FIG. **2**. An endless timing belt **31** connected to a rear end (a mounting portion **30** as will be described later) of the carriage **19** extends between the pulleys **28** and **29**.

Upon drive of the X-axis motor **26**, normal or reverse rotation of the X-axis motor **26** is transmitted via the second reduction gear mechanism **27** and the pulley **28** to the timing belt **31**, whereby the carriage **19** is moved leftward or rightward together with the cutter holder **5**. Thus, the carriage **19** and the cutter holder **5** are moved in the X direction perpendicular to the Y direction in which the object **6** is conveyed. The second moving unit **8** is constituted by the above-described guide shaft **20**, the guide frame **21**, the X-axis motor **26**, the second reduction gear mechanism **27**, the pulleys **28** and **29**, the timing belt **31**, the carriage **19** and the like.

The cutter holder **5** is disposed on the front of the carriage **19** and is supported so as to be movable in a vertical direction (a third direction) serving as a Z direction. The carriage **19** and the cutter holder **5** will be described with reference to FIGS. **3** to **7** as well as FIGS. **1** and **2**. The carriage **19** is formed into the shape of a substantially rectangular box with an open rear as shown in FIGS. **2** and **3**. The carriage **19** has an upper wall **19***a* with which a pair of upwardly protruding front and rear guided members **23** are integrally formed. The guided members **23** are arc-shaped ribs as viewed in a planar view. The guided members **23** are symmetrically disposed with a front edge **21***a* of the guide frame **21** being interposed therebetween. The carriage **19** has a bottom wall **19***b* further having a downwardly expanding portion which is formed with a pair of right and left through holes **22** through which the guide shaft **20** is inserted, as shown in FIGS. **4**, **5** and **6**. An attaching portion **30** (see FIGS. **5** and **6**) is mounted on the bottom wall **19***b* of the carriage **19** so as to protrude rearward. The attaching portion **30** is to be coupled with the timing belt **31**. The carriage **19** is thus supported by the guide shaft **20** inserted through the holes **22** so as to be slidable in the right-left direction and further supported by the guide frame **21** held between the guided members **23** so as to be prevented from being rotated about the guide shaft **20**.

The carriage **19** has a front wall **19***c* with which a pair of upper and lower support portions **32***a* and **32***b* are formed so as to extend forward as shown in FIGS. **3** to **5**, **11**, etc. A pair of right and left support shafts **33***b* and **33***a* extending through the respective support portions **32***a* and **32***b* are mounted on the carriage **19** so as to be vertically movable. A Z-axis motor **34** comprising, for example, a stepping motor is accommodated in the carriage **19** backward thereby to be housed therein. The Z-axis motor **34** has a rotating shaft **34***a* (see FIGS. **3** and **11**) which extends through the front wall **19***c* of the carriage **19**. The rotating shaft **34***a* has a distal end provided with a gear **35**. Furthermore, the carriage **19** is provided with a gear shaft **37** which extends through a slightly lower part of the gear **35** relative to the central part of the front wall **19***c* as shown in FIGS. **5**, **6** and **11**. A gear **38** is rotatably mounted on the gear shaft **37** and adapted to be brought into mesh engagement with the gear **35** in front of the front wall **19***c* is rotatably mounted on the gear shaft **37**. The gear **38** is retained by a retaining ring (not shown) mounted on a front end of the gear shaft **37**. The gears **35** and **38** constitute a third reduction mechanism **41** (see FIGS. **3** and **11**).

The gear **38** is formed with a spiral groove **42** as shown in FIG. **7**. The spiral groove **42** is a cam groove formed into a spiral shape such that the spiral groove **42** comes closer to the center of the gear **38** as it is turned rightward from a first end **42***a* toward a second end **42***b*. An engagement pin **43** which is vertically moved together with the cutter holder **5** engages the spiral groove **42** (see FIGS. **5** and **6**) as will be described in detail later. Upon normal or reverse rotation of the Z-axis motor **34**, the gear **38** is rotated via the gear **35**. Rotation of the gear **38** vertically slides the engagement pin **43** in engagement with the spiral groove **42**. With the vertical slide of the gear **38**, the cutter holder **5** is moved upward or downward together with the support shafts **33***a* and **33***b*. In this case, the cutter holder **5** is moved between a raised position (see FIGS. **5** and **7**) where the engagement pin **43** is located at the first end **42***a* of the spiral groove **42** and a lowered position (see FIGS. **6** and **7**) where the engagement pin **43** is located at the second end **42***b*. A third moving unit **44** which moves the cutter holder **5** upward and downward is constituted by the above-described third reduction mechanism **41** having the spiral groove **42**, the Z-axis motor **34**, the engagement pin **43**, the support portions **32***a* and **32***b*, the support shafts **33***a* and **33***b*, etc.

The cutter holder **5** includes a holder body **45** provided on the support shafts **33***a* and **33***b*, a movable cylindrical portion **46** which has a cutter **4** (a cutting blade) and is held by the holder body **45** so as to be vertically movable and a pressing device **47** which presses the object **6**. More specifically, the holder body **45** has an upper end **45***a* and a lower end **45***b* both of which are folded rearward such that the holder body **45** is generally formed into a C-shape, as shown in FIGS. **3** to **5**, **11** and the like. The upper and lower ends **45***a* and **45***b* are immovably fixed to the support shafts **33***a* and **33***b* by retaining rings **48** fixed to upper and lower ends of the support shafts **33***a* and **33***b*, respectively. The support shaft **33***b* has a middle part to which is secured a coupling member **49** provided with a rearwardly directed engagement pin **43** as shown in FIGS. **5** and **6**. The holder body **45**, support shafts **33***a* and **33***b*, the engagement pin **43** and the coupling member **40** are formed integrally with one another as shown in FIGS. **5** and **6**. The cutter holder **5** is vertically moved by the third moving unit **44** in conjunction with the engagement pin **43**. Furthermore, compression coil springs **50** serving as biasing members are mounted about the support shafts **33***a* and **33***b* so as to be located between upper surfaces of the support portion and upper end of the holder boy **45**, respectively. The entire cutter holder **5** is elastically biased upward by a biasing force of the compression coil springs **50** relative to the carriage **19**.

Mounting members **51** and **52** provided for mounting the movable cylindrical portion **46**, the pressing device **47** and the like are fixed to the middle portion of the holder body **45** by screws **54***a* and **54***b* respectively, as shown in FIGS. **3** and **4**. The lower mounting member **52** is provided with a cylindrical portion **52***a* (see FIG. **5**) which supports the movable cylindrical portion **46** so that the movable cylindrical portion **46** is vertically movable. The movable cylindrical portion **46** has a diameter that is set so that the movable cylindrical portion **46** is brought into a sliding contact with the inner peripheral surface of the cylindrical portion **52***a*. The movable cylindrical portion **46** has an upper end on which a flange **46***a* supported on an upper end of the cylindrical portion **52***a* is formed so as to expand radially outward. A spring shoe **46***b* is provided on an upper end of the flange **46***a*. A compression coil spring **53** is interposed between the upper mounting member **51** and the spring shoe **46***b* of the movable cylindrical portion **46** as shown in FIGS. **5** and **6**. The compression coil spring **53** biases the movable cylindrical portion **46** (the cutter **4**) to the lower object **6** side while allowing the upward movement of the movable cylindrical portion **46** against the biasing force when an upward force acts on the cutter **4**.

The cutter **4** is provided in the movable cylindrical portion **46** so as to extend therethrough in the axial direction. In more detail, the cutter **4** has a round bar-like cutter shaft **4***b* which is longer than the movable cylindrical portion **46** and a blade **4***a* integrally formed on a lower end of the cutter shaft **4***b*. The blade **4***a* is formed into a substantially triangular shape and has a lowermost blade edge **4***c* formed at a location offset by a distance d from a central axis O of the cutter shaft **4***b*, as shown in FIG. **8**. The cutter **4** is held by bearings **55** (see FIG. **5**) mounted on upper and lower ends of the movable cylindrical portion **46** so as to be rotatably movable about the central axis O (the Z axis) in the vertical direction. Thus, the blade edge **4***c* of the cutter **4** presses an X-Y plane or the surface of the object **6** from the Z direction perpendicular to the X-Y plane. Furthermore, the cutter **4** has a height that is set so that when the cutter holder **5** has been moved to a lowered position, the blade edge **4***c* passes through the object **6** on the holding sheet **10** but does not reach the upper surface of the plate member **3***b* of the platen **3**, as shown in FIG. **8**. On the other hand, the blade edge **4***c* of the cutter **4** is moved upward with movement of the cutter holder **5** to the raised position, thereby being departed from the object **6** (see FIG. **5**).

Three guide holes **52***b*, **52***c* and **52***d* (see FIGS. **3** to **5** and **11**) are formed at regular intervals in a circumferential edge of the lower end of the cylindrical portion **52***a*. A pressing member **56** is disposed under the cylindrical portion **52***a* and has three guide bars **56***b*, **56***c* and **56***d* which are to be inserted into the guide holes **52***b* to **52***d* respectively. The pressing member **56** includes a lower part serving as a shallow bowl-shaped pressing portion body **56***a*. The aforementioned equally-spaced guide bars **56***b* to **56***d* are formed integrally on the circumferential end of the top of the pressing portion body **56***a*. The guide bars **56***b* to **56***d* are guided by the respective guide holes **52***b* to **52***d*, so that the pressing member **56** is vertically movable. The pressing portion body **56***a* has a central part formed with a through hole **56***e* which vertically extends to cause the blade **4***a* to pass therethrough. The pressing portion body **56***a* has an underside serving as a contact portion **56***f* which is brought into contact with the object **6** while the blade **4***a* is located in the hole **56***e*. The contact portion **56***f* is formed into an annular horizontal flat surface and is brought into surface contact with the object **6**. The contact portion **56***f* is made of a fluorine resin such as Teflon® so as to have a lower coefficient of friction, whereupon the contact portion **56***f* is rendered slippery relative to the object **6**.

The pressing portion body **56***a* has a guide **56***g* which is formed integrally on the circumferential edge thereof so as to extend forward, as shown in FIGS. **3** to **5** and **11**. The guide **56***g* is located in front of and above the contact portion **56***f* and includes an inclined surface **56***ga* inclined rearwardly downward to the contact portion **56***f* side. Consequently, when the holding sheet **10** holding the object **6** is moved rearward relative to the cutter holder **5**, the object **6** is guided downward by the guide **56***g* so as not to be caught by the contact portion **56***f*.

The mounting member **52** has a front mounting portion **52***e* for the solenoid **57**, integrally formed therewith. The front mounting portion **52***e* is located in front of the cylindrical portion **52***a* and above the guide **56***g*. The solenoid **57** serves as an actuator for vertically moving the pressing member **56** thereby to press the object **6** and constitutes a pressing device **47** (a pressing unit) together with the pressing member **56** and a control circuit **61** which will be described later. The solenoid **57** is mounted on the front mounting portion **52***e* so as to be directed downward. The solenoid **57** includes a plunger **57***a* having a distal end fixed to the upper surface of the guide **56***g*. When the solenoid **57** is driven with the cutter holder **5** occupying the lowered position, the pressing member **56** is moved downward together with the plunger **57***a* thereby to press the object **6** with a predetermined pressure (see FIG. **11**). On the other hand, when the plunger **57***a* is located above during non-drive of the solenoid **57**, the pressing member releases the object **6** from application of the pressing force. When the cutter holder **5** is moved to the raised position during non-drive of the solenoid **57** (see two-dot chain line in FIG. **5**), the pressing member **56** is completely departed from the object **6**.

The holding sheet **10** has an adhesive layer **10***a* (see FIG. **8**) which holds the object **6**. The object **6** is immovably held on the holding sheet **10** by a resultant force of adhesion of the adhesive layer **10***a* and a pressing force of the pressing device **47**. The configurations of the holding sheet **10** and the pressing device **47** will now be described with additional reference to FIGS. **8** and **9**. The holding sheet **10** is made of, for example, a synthetic resin and formed into a flat rectangular plate shape, as shown in FIG. **1**. The holding sheet **10** is placed opposite the cutter **4** and has a side (a side opposite the cutter **4**) on which an adhesive layer **10***a* (see FIG. **8**) is formed by applying an adhesive agent to the holding sheet **10**. The sheet-like object **6** such as paper, cloth, resin film or the like is removably held by the adhesive layer **10***a*. The adhesive layer **10***a* has an adhesion that is set to a small value such that the object **6** can easily be removed from the adhesive layer **10***a* without breakage of the object **6**.

When reference symbol F_N designates a holding force necessary to hold the object **6** so that the object **6** is immovable relative to the holding sheet **10**, the adhesive layer **10***a* is set at an adhesion F_S that is smaller than F_N. More specifically, the adhesion F_S is weaker than in the conventional structure in which the object is held only by the adhesion of the adhesive layer. The pressing force F_P of the pressing device **47** by actuation of the solenoid **47** is set so that a resultant force of the pressing force F_P and the adhesion F_S of the adhesive layer **10***a* meets the necessary holding force F_N. The necessary holding force F_N in this case is shown by the following equation (1):

$$F_N \leq F_S + F_P \tag{1}$$

In the cutting apparatus **1**, the resultant force of the pressing force F_P and the adhesion F_S is thus set to be not less than the necessary holding force F_N so that the object **6** is prevented from being displaced from the holding sheet **10** when the object **6** is cut by the cutter **4**.

FIG. **9** shows the relationship between the adhesion F_S of the adhesive layer **10***a* and the objects **6**A and **6**B. In the case where the adhesion F_S of the adhesive layer **10***a* exceeds FA_H, the object **6**A is broken when removed from the adhesive layer **10***a*, and the object **6**A cannot be held when the adhesion F_S is less than FA_L. Accordingly, the adhesion F_S can be ranged from FA_H to FA_L. On the other hand, the object **6**B cannot be held by the holding member **10** when the adhesion F_S is not equal to or not larger than FB_H, and in the case where the object **6**B is broken when the adhesion F_S is larger than FB_L. Accordingly, the object is displaced from the holding sheet during the cutting in the conventional construction no matter how carefully the adhesion is adjusted, or the object **6**B is broken when removed from the holding sheet. The conventional construction thus has the above-described problems.

In the embodiment, however, the pressing force F_P of the pressing device **47** is set at the value corresponding to the difference (FB_H–FB_L) regarding the object **6**B. In this case, even when F_S is equal to FB_L, the object **6**B can be held on the holding sheet **10** during cutting, and the object **6**B can be prevented from breakage when removed from the holding sheet **10**. Thus, the pressing force F_P and the adhesion F_S of the adhesive layer **10** are set according to the type, property of the object **6** or the like so that the object **6**B on the holding sheet **10** can reliably be prevented from displacement during cutting and the object **6**B can be prevented from breakage when removed from the holding sheet **10**. The resultant force of the foregoing pressing force F_P and the adhesion F_S designates a single force which has an equal effect to these plural forces F_P and the adhesion F_S.

The arrangement of the control system of the cutting apparatus **1** will now be described with reference to a block diagram of FIG. **10**. A control circuit (a control unit) **61** controlling the entire cutting apparatus **1** mainly comprises a computer (CPU) as shown in FIG. **10**. A ROM **62**, a RAM **63** and an external memory **64** each serving as a storage unit are connected to the control circuit **61**. The ROM **62** stores a cutting control program for controlling the cutting operation, the threshold of a cutting angle and various control data and the like. The external memory **64** stores data of a plurality of cutting data and the like. The RAM **63** is provided with storage areas for temporarily storing various data and program necessary for execution of each processing.

Operation signals are supplied from the various operation switches **65** to the control circuit **61**. The control circuit **61** controls a displaying operation of the LCD **9**. In this case, while viewing the displayed contents of the LCD **9**, the user operates the switches **65** to select and designate cutting data of a desired pattern. Detection signals are also supplied from various sensors **66** such as a sensor for detecting the holding sheet **10** set from the opening **2***a* of the cutting apparatus **1**. To the control circuit **61** are connected drive circuits **67** to **70** driving the Y-axis, X-axis and Z-axis motors **15**, **26** and **34** and the solenoid **57**. Upon execution of the cutting control program, the control circuit **61** controls various actuators such as the Y-axis, X-axis and Z-axis motors **15**, **26** and **34** and the solenoid **57**, based on the cutting data, whereby the cutting operation is automatically executed for the object **6** on the holding sheet **10**.

The control circuit **61** is configured as a control unit which controls the current supplied to the solenoid **57** to set the pressing force of the pressing device **47** at the aforesaid F_P. More specifically, the control circuit **61** controls the solenoid **57** to protrude the plunger **57***a* downward so that the pressing force FP is generated at the contact portion **56***f* of the pressing member **56** against the object **6**. The pressing device **47** thus presses the object **6** against the contact surface of the object **6** in the Z direction perpendicular to the contact surface of the object **6**, with which the contact portion **56***f* is brought into contact. The control to set the pressing force FP is adapted to be executed as a pressing force setting routine when the object **6** is cut by the cutter **4**.

The operation of the cutting device **1** will be described. The cutter holder **5** occupies a raised position before the object **6** is cut, as shown in FIG. **5**. In this state, the user affixes the object **6** to the adhesive layer **10***a* such that the object **6** is held by the holding sheet **10**. The user then sets the holding sheet **10** to the cutting apparatus **1** from the opening **2***a* and operates the operation switches **65** to select, for example, a desired one of the cutting data stored in the external memory **64** so that a cutting operation is executed. Upon start of the cutting operation, the holding sheet **10** is firstly held between the driving roller **12** and the pinch roller **13** to be conveyed in the Y direction in order that the object **6** may be moved to a cut starting point. In this case, the object **6** is prevented from being caught by the contact portion **56***f* of the pressing member **56** even when the solenoid **57** is driven before the object **6** reaches the cut starting position. More specifically, the pressing member **56** is formed with a guide **56***g* having an inclined surface inclined toward and continuous to the contact portion **56***f*. Accordingly, the guide **56***g* prevents the object **6** from being caught by the contact portion **56***f* even when the set holding sheet **10** is moved rearward while the pressing member **56** occupies a position shown by solid line in FIG. **5**.

When the object **6** has reached the cut starting point, the Z-axis motor **34** is driven to move the cutter holder **5** to the lowered position (see FIG. **11**). The holding sheet **10** and the cutter **4** of the cutter holder **5** are moved relative to each other by the first and second moving units **7** and **8** on the basis of the cutting data respectively, whereby the object **6** is cut. The contact portion **56***f* applies the pressing force F_P to the object **6** as the result of drive of the solenoid **57** during the cutting operation. Accordingly, the object **6** is held by both the adhesion F_S of the adhesive layer **10***a* of the holding sheet **10** and the pressing force F_P so as not to be displaced relative to the holding sheet **10**. Furthermore, the pressing member **56** is moved relative to the object **6** during the cutting. However, since the contact portion **56***f* of the pressing member **56** is made of a material having a lower frictional coefficient than the object **6**, a frictional force produced between the contact portion **56***f* and the object **6** can be reduced as much as possible. Consequently, the object **6** can be prevented from displacement due to the frictional force, whereupon the object can be held more reliably.

When the cutting of the object **6** has been finished, the user removes the object **6** from the holding sheet **10**. In this case, since the adhesive layer **10***a* of the holding sheet **10** has the adhesion set at the value F_S, the object **6** can easily be removed from the holding sheet **10**.

As described above, the pressing force F_P is set at the value such that the resultant force of the adhesion F_S of the adhesive layer **10***a* and the pressing force F_P of the pressing device **47** meets the holding force F_N necessary to immovably hold the object **6** relative to the holding sheet **10** when the object **6** is cut by the cutter **4**.

Consequently, the object **6** can immovably be held on the holding sheet **10** by the resultant force of the adhesion F_S of the adhesive layer **10***a* and the pressing force F_P of the pressing device **47**. Accordingly, the object **6**, when cut, can reliably be prevented from displacement on the holding sheet **10**, whereupon the object **6** can accurately be cut into a desired shape. Since the necessary holding force required of the holding sheet **10** can be compensated for by the pressing force FP of the pressing device **47**, the adhesion F_S

of the adhesive layer **10**a can be set to be weaker than in the conventional construction in which the object is held on the holding member only by the adhesion. Thus, the object **6** can easily be removed from the holding sheet **10** (the adhesive layer) without breaking the holding sheet after, for example, a sheet such as paper, serving as the object **6** has been cut.

The pressing device **47** includes the contact portion **56**f which is brought into contact with the object **6** and made of the material with the lower frictional coefficient. The contact portion **56**f can reduce the frictional force between the pressing member **56** and the object **6**. Accordingly, the relative movement of the object **6** can smoothly be carried out while the object **6** is being pressed by the contact portion **56**f of the pressing device **47**.

The pressing device **47** is configured to press the object **6** in the direction perpendicular to the contact surface of the object **6** brought into contact with the contact portion **56**f. Consequently, since the contact portion **56**f can efficiently press the object **6**, the object **6** can reliably be held.

The pressing device **47** includes the guide **56**g which guides the object **6** to prevent the object **6** held by the holding sheet **10** from being caught by the contact portion **56**f. The object **6** can be held so as not to displace on the holding sheet **10**. Consequently, the object **6** can be cut more accurately.

Second Embodiment

FIG. **12** illustrates a second embodiment. Only the difference between the first and second embodiments will be described. Identical or similar parts in the second embodiment are designated by the same reference symbols as those in the first embodiment. The cutter holder **5'** in the second embodiment differs from the cutter holder **5** of the first embodiment in the following. The solenoid **57**, the mount **52**e and the like are eliminated in the cutter holder **5'** and a compression coil spring **53** is disposed between the pressing member **56'** and the movable cylinder **46**. The pressing member **56'** is held at a predetermined vertical position relative to the holder body **45**. When the cutter holder **5'** occupies the lowered position as shown in FIG. **12**, the contact portion **56**f of the pressing member **56** presses the object **6** with the aforementioned pressing force F_P. Thus, the pressing device **47'** is constituted by the pressing member **56'**, the third moving unit **44**, the control circuit **61**, the compression coil spring **44** and the like. Consequently, the control to set the pressing force FP is executed by vertically moving the cutter holder **5** by the third moving unit **44**.

Furthermore, the pressing member **56'** has the guide **56**g' formed integrally therewith. The guide **56**g' extends obliquely upward in front of the contact portion **56**f. The guide **56**g' is formed into an arc shape and is continuous to the contact portion **56**f so as to be inclined toward the contact portion **56**f. As a result, as shown in FIG. **12**, even if a part of the object **6** is turned upward from the holding sheet **10**, the object **6** is guided by the guide **56**g' so as not to be caught by the contact portion **56**f in the same manner as the guide portion **56**g.

In the second embodiment, the solenoid **57** and the like are eliminated and the pressing member **56'** is held via the compression coil spring **53** at the predetermined position on the holder body **45**, as described above. Thus, the pressing force F_P applied to the object **6** can be obtained by the simple construction. Furthermore, the pressing force F_P is suitably adjustable by changing the spring constant of the compression coil spring **53**. Furthermore, the guide portion **56**g can prevent the object **6** from being caught by the contact portion **56**f or the vicinity thereof. The second embodiment can thus achieve substantially the same effect as the first embodiment.

Meanwhile, since the conventional cutting apparatus is not provided with a pressing unit applying the pressing force F_P to the object, there is a possibility that the object may displace from the sheet-like member during the cutting even when the sheet-like member has an adhesive layer. In particular, the cutter **100** as shown in FIG. **17** is rotatable about the axis O and accordingly, there is a possibility that corners of a cutting line of the sheet **105** as the object to be cut cannot be accurately cut. For example, when a cutting line is composed of first and second line segments which are formed into a V shape, the blade edge of the cutter **100** is directed to the direction of the first line segment at a cutting end point of the first line segment. Thereafter, the blade edge of the cutter **100** is changed to the direction of the second line segment when the cutting of the second line segment starts. As a result, even when the aforesaid sheet-like member is used, the corner where the direction of the blade edge of the cutter **100** is changed may cause burr during the cutting. This problem is more noticeable when an angle made between the first and second segments is acute or when the sheet **105** has a large thickness. Thus, it has been difficult to sufficiently hold the object so that the corners can be prevented from being burred in spite of the adhesion of the sheet-like member.

In view of the above-described problem, the cutting apparatus of the following third embodiment specifies a region, such as the aforesaid corners, which is located along a cutting line of the object **6** and in which the adhesive holding force is relatively insufficient. The pressing force F_P is changed between the case where the specified region is cut and the case where apart other than the specified region is cut, so that burr is reliably prevented from occurring at the corners. In the following description, a case where the pattern of a star is cut from the object **6** held by the holding sheet **10** as shown in FIG. **13**A.

Third Embodiment

FIGS. **13**A to **16** illustrate the third embodiment. Only the differences between the first and third embodiments will be described. The identical or similar parts in the third embodiment are labeled by the same reference symbols as those in the first embodiment.

Firstly, the cutting data includes line segment data corresponding to n number of line segments L_1 to L_n composing the cutting line L. For example, when the pattern of a star is cut out of the object as shown in FIG. **13**A, the cutting data has data of ten line segments comprising ten line segments L_1 to L_n composing the cutting line L. More specifically, the line segments L_1 to L_{10} have start points L_{1S} to L_{10S} and end points L_{1E} to L_{10E} respectively. The line segments L_1 to L_{10} are continuous and constitute a closed single cutting line. Accordingly, start points of the line segments correspond with end points of the neighboring line segments respectively. The start and end points of the line segments L_1 to L_{10} of the line segment data are shown by X-Y coordinates respectively. The X-Y coordinates have as an origin an apex located at the rear side in the Y-axis direction as a sheet feeding direction and at the start point side in the direction of the X-axis as a moving direction of the cutter **4**.

The RAM **63** stores the cutting data including the above-mentioned data of n number of line segments read from the external memory **64**. Consequently, when the object **6** is cut by the cutting apparatus **1**, the line segments L_1 to L_{10} are cut based on the cutting data stored in the RAM **63**. In this case, in the cutting of the object **6** by the cutting apparatus **1**, the holding sheet **10** (the object **6**) is conveyed in the Y direction by the first moving unit **7** of the cutting apparatus **1** and the cutter holder **5** is moved in the X direction by the second moving unit **8**, based on the cutting data, whereby the cutter **4** is moved to the X-Y coordinate of the start point L_{1S} of the line segment L_1 relative to the holding sheet **10** with the object **6**. Subsequently, the blade edge **4***c* of the cutter **4** is caused to pass through the start point L_{1S} of the object **6** by the third moving unit **44**. The holding sheet **10** with the object **6** and the cuter holder **5** with the cutter **4** are then moved by the first and second moving units **7** and **8** relative to each other respectively thereby to be moved toward the coordinate of the end point L_{1E} of the line segment L_1, whereby the object **6** is cut along the line segment L_1. The subsequent line segment L_2 is continuously cut in the same manner as the line segment L_1 with the previous line segment L_1 serving as the start point L_{2S}. The cutting is also executed continuously in the cutting sequence of the line segment data with respect to each of the line segments L_2 to L_{10}, whereupon the cutting line L of the star pattern is cut.

The threshold of the cutting angle stored in the ROM **62** is indicative of an angle θ made between neighboring line segments L_1 and L_2 as shown in FIG. **13**B. The threshold T of the cutting angle is set at a predetermined value (130°, for example) and compared with the angle θ made between an (i−1)-th line segment L_{i-1} to be cut and an i-th line segment L_i to be cut. When the angle θ is not more than the threshold T, the control circuit **61** specifies a region around apex P as a region **A1** where an adhesive retention of the adhesive layer **10***a* is insufficient along the cutting line L. The control circuit **61** thus constitutes a region specifying unit. The region **A1** is specified on the basis of the threshold T. For example, the region **A1** includes a part that is easily turned upward during cutting, such as an acute-angled corner made between the line segments L_1 and L_2 as shown in FIG. **13**B, or a part including a corner that is easily drooped. The easily drooped corner refers to a slightly rounded distal end of a corner. In this case, for example, reference symbol "**A1**" designates a region in the range of a predetermined distance from the apex P of the corner and reference symbol "**A2**" designates a region other than the region **A1**. Accordingly, the region **A2** includes a part other than the region **A1** and an obtuse-angled portion where the cutting angle exceeds the predetermined value.

The blade edge **4***c* of the cutter **4** is offset from the central axis O of the cutter **4** by the distance d as described above (see FIG. **8**), so that the blade edge **4***c* is subjected to a resistive force (hereinafter referred to as "cutting resistive force") from the object **6** with relative movement of the cutter **4** and the object **6**. Accordingly, the cutter **4** is turned about the central axis O or in other words, with the relative movement of the cutter **4** and the object **6**, the cutter **4** automatically changes its direction along the direction of the relative movement.

More specifically, cutting is firstly carried out along the line segment L_1 in the direction of arrow when the corner of the region **A1** in the cutting line L of the star is cut, as shown in FIG. **13**B. In this case, when the cutting blade **4***a* of the cutter **4** has reached the apex P (end point L_{1E}), the central axis O occupies a position located away by distance d from the apex P on an extended line from the line segment L_1. Since the blade edge **4***c* is subsequently changed to the direction along the line segment L_2, the cutter **4** is moved so that the central axis O is along the broken line (arc). Thereafter, the line segment L_2 is cut. In this case, the blade edge **4***c* passes through the object **6**, biting slightly into the holding sheet **10**, as shown in FIG. **8**. Accordingly, a part corresponding to the apex P is slightly burred by the blade edge **4***c*. Furthermore, the part has a region which is in contact with the adhesive layer **10***a* and gradually becomes smaller and the adhesion retention of the adhesive layer **10***a* become weaker as it comes close to the distal end thereof. As a result, the corner of the region **A1** is turned upward or burred. This problem is noticeable when the cutting angle θ is acute and/or the sheet is thick.

In view of the problem, the control circuit **61** in the embodiment is configured to control the current supplied to the solenoid **57** so that the pressing force of the pressing device **47** pressing the object **6** is changed or differentiated between a case where the region **A1** is cut and a case where the region **A2** other than the region **A1** is cut. More specifically, in the case where the region **A1** is cut, a resultant force of the adhesion F_S of the adhesive layer **10***a* of the holding sheet **10** and the pressing force F_{P1} is set to meet a holding force F_{N1} necessary to hold the object **6** so that the corner of the region **A1** is not turned over (or the corner is burred). The necessary holding force F_{N1} in this case is shown by the following expression (2):

$$F_{N1} \leq F_S + F_{P1} \tag{2}$$

Furthermore, in the case where the region **A2** is cut, a resultant force of the adhesion F_S of the adhesive layer **10***a* of the holding sheet **10** and the pressing force F_{P2} of the pressing device **47** is set to meet a holding force F_{N2} necessary to hold the object **6** so that the object **6** is immovably held by the holding sheet **10** against the cutting resistance in the region **A2**. The necessary holding force F_{N2} in this case is shown by the following expression (3):

$$F_{N2} \leq F_S + F_{P2} \tag{3}$$

In this case, since the pressing force F_{P1} in the region **A1** is set so as to be stronger or larger than the pressing force F_{P2} in the region **A2** ($F_{P1} > F_{P2}$), the corner can accurately be cut in the region **A1** without causing the above-described problem. On the other hand, since the pressing force F_{P2} in the region **A2** is weaker than the pressing force F_{P1}, the load resulting from the relative movement of the cutter **4** and the object **6** can be reduced.

The control circuit **61** is configured as a control unit which controls the current supplied to the solenoid **57** to set the pressing force of the pressing device **47** at the aforementioned F_{P1} or F_{P2}. More specifically, the control circuit **61** controls the solenoid **57** to be thrust downward so that the contact portion **56***f* of the pressing member **56** presses the object **6** with the pressing force F_{P1} or F_{P2}. The contact portion **56***f* of the pressing device **47** thus presses the object **6** in the Z direction perpendicular to the contact surface of the object **6**.

The control circuit **61** is also configured as a speed control unit which controls the rotational speeds of the Y-axis and X-axis motors **15** and **26** in association with the pressing forces F_{P1} and F_{P2} of the pressing device **47**. More specifically, when the region **A1** is to be cut, the control circuit **61** controls the motors **15** and **26** so that the relative moving speeds of the cutter **4** and the object **6** are the respective lower or first speeds. When the region **A2** is to be cut, the control circuit **61** drives the motors **15** and **26** so that the relative moving speeds of the cutter **4** and the object **6** are the respective second speeds that are higher than the first speeds.

A concrete processing procedure of the cutting operation of the cutting apparatus **1** will now be described with reference to FIGS. **14** to **16**, which are flowcharts showing processing flows of the cutting control program executed by the control circuit **61** respectively. In the figures, a symbol Si (where i=11, 12, 13 and . . .) designates each step. The shape to be cut is the aforesaid "star" and ordinary paper is used as the object **6**.

When the object **6** is to be cut by the cutting apparatus **1**, the user sets the holding sheet **10** holding the object **6**, from the opening **2***a* of the cutting apparatus **1** in the same manner as in the first embodiment. When the user has selected desired cutting data stored in the external memory, for example, the selected cutting data is stored in a memory of the RAM **63**. Upon operation of the operation switches **65**, the control circuit **61** starts the cutting operation based on the operation signal (step S**11**).

In the cutting operation, firstly, the moving speed of the cutter **4** relative to the object **6** is set at an initial set speed (the second speed (higher speed), for example) (step S**12**). Subsequently, the Y-axis and X-axis motors **15** and **26** are driven so that the blade edge **4***c* of the cutter **4** is moved to the cutting start point L_{is} of the object **6** (see FIG. **13**B). In this case, the cutter **4** is moved at a higher speed in the X-Y direction relative to the object **6** while being vertically located away from the object **6**. When the cutter **4** has been moved to the cutting start point L_{1S}, the control circuit **61** drives the solenoid **57** so that the pressing member **56** presses the object **6** with a relatively weaker pressing force F_{P2} (step S**14**). The control circuit **61** further drives the Z-axis motor **34** so that the cutter holder **5** is moved to the lowered position, whereby the blade edge **4***c* of the cutter **4** is caused to pass through the cutting start point L_{1S} (step S**15**).

The motors **15** and **26** are driven to move the holding sheet **10** and the cutter **4** respectively so that the cutter **4** is moved to the coordinate (see FIG. **13**B) of end point L_{1E} of the line segment L_1, whereby the cutting of the line segment L_1 is started (S**16**). In this case, a second speed setting processing for the Y-axis and X-axis motors **15** and **26** is executed at step S**17** (see FIG. **15**). In the second speed setting processing, when the relative speed of the cutter **4** is set at the first speed (lower speed) (YES at step S**31**), the relative speed of the cutter **4** is changed to the second speed (higher speed). Since the relative speed of the cutter **4** has been set at the second speed (higher speed) by the initial setting (NO at step S**31**), the change to the second speed will be described later (the control circuit **61** returns to step S**18** in FIG. **14**).

The control circuit **61** computes the angle θ made by the line segment L_1 including the cutting start point L_{1S} and the line segment L_2 to be subsequently cut, based on the line segment data of L_2. When the angle θ exceeds the threshold T (NO at step S**18**), the cutter **4** is moved to the endpoint L_{1E} while the second speed is maintained (step S**19**). On the other hand, when the angle θ is not more than the threshold T, that is, when an acute corner such as apex P in FIG. **13**B is to be cut (YES at step S**18**), a first speed setting processing is executed at step S**20** (see FIG. **16**).

In the first speed setting processing, it is determined whether or not a remaining length of the currently cut line segment L_1 is shorter than the distance a at step S**41**. In this case, the control circuit **61** is on standby for the remaining length being reduced below the distance a (when the cutter **4** reaches the region A1), the relative moving speed of the cutter **4** is changed from the second speed (higher speed) to the first speed (lower speed), whereupon the cut **4** is set at the lower speed (step S**42**). Simultaneously, the control circuit **61** controls a drive current of the solenoid **57** to change the pressing force of the pressing device **47** from F_{P2} to F_{P1} (step S**43**). As a result, the object **6** is pressed by the contact portion **56***f* of the pressing member **56** with the pressing force F_{P1} in the region A1 (FIG. **13**B) so that the object **6** is not turned upward. In this state, the cutter **4** is moved so that the blade edge **4***c* thereof reaches the apex P (end point L_{1E} of L_1) (step S**44**). Thereafter, the control circuit **61** returns to step S21 in FIG. **14**.

The control circuit **61** determines at step S21 whether or not the blade edge **4***c* of the cutter **4** is currently located at the endpoint L_{10E} of the cutting line L, that is, whether or not the cutting of all the line segments L_1 to L_{10} has ended. In this case, since the line segments L_2 to L_{10} have not been cut (NO at step S**21**), the control circuit **61** starts the cutting of the line segment L_2 until the end point L_{2E} is reached (step S**16**). The second speed setting processing is executed at step S**17** (see FIG. **15**).

In the second speed setting processing, the control circuit **61** determines at step S**31** whether or not the moving speed of the cutter **4** relative to the object **6** is set at the first speed (lower speed). When determining that the moving speed of the cutter **4** relative to the object **6** is set at the first speed (YES at step S**31**) and that the line segment L_2 exceeds the distance a (YES at step S**32**), the control circuit **61** determines that the moving speed of the cutter **4** relative to the object **6** is set at the first speed (lower speed) in the cutting of the line segment L_2 and maintains the pressing force F_{P1}. More specifically, when the blade edge **4***c* has reached the apex P, the cutter **4** is changed to the direction of the line segment L_2, whereupon a clear acute cutting can be executed. Moreover, since the moving speed of the cutter **4** relative to the object **6** is set at the first speed (lower speed), a continuous stable cutting can be executed without step-out of the motors **15** and **26** in spite of strong pressing force F_{P1}. Thus, when having finished the cutting of the line segment L_2 by distance a (region A_1) (YES step A**33**), the control circuit **61** changes the pressing force of the pressing device **47** from F_{P1} to F_{P2} (step S**34**). The control circuit **61** further changes the moving speed of the cutter **4** relative to the object **6** from the first speed (lower speed) to the second speed (higher speed). More specifically, the control circuit **61** sets the relative moving speed of the cutter **4** to the second speed (higher speed) (step S**35**), returning to step S**18** in FIG. **14**. When determining at step S**32** that the length of the line segment L_2 has not exceeded the distance a, the control circuit **61** maintains the pressing force F_{P1} in the cutting of the line segment L_2 and the first speed (lower speed).

The control circuit **61** computes an angle θ made between the line segment L_2 and the line segment L_3 to be subsequently cut, based on line segment data of L_3. The control circuit **61** then compares an angle α obtained by computation with the threshold T, thereby executing the same cutting processing as the first line segment L_1 with respect to line segment L_2 or the first speed setting processing (steps S**19** and S**20**). Steps S**16** to S**21** are thus repeated in the sequence of line segments L_1 to L_{10}, the cutting processing is executed with the suitable moving speed and the suitable pressing forces F_{P1} and F_{P2} for every regions **A1** and **A2** in each of the line segments L_1 to L_{10}. Furthermore, since the pressing force is increased at five corners as shown by "P" in FIG. **13**A in the cutting processing, the object can be cut with clear acute lines. When determining that the cutting has been executed up to the end point L**10**E of the cutting line L of the "star" pattern (YES at step S**21**), the control circuit **61** moves the cutter holder **5** to the raised position (step S**22**), deactivates the solenoid **57** and moves the pressing member **56** upward (step S**23**), ending the processing.

Upon finishing the cutting of the object **6**, the user removes the object **6** from the holding sheet **10**. In this case, since the adhesion of the adhesive layer **10***a* of the holding sheet **10** is set at the aforesaid value F_S, the object **6** can easily be removed from the holding sheet **10**. In the third embodiment, steps S**17**, S**20**, S**34** and S**43** serve as a pressing force setting routine of setting the pressing forces F_{P1} and F_{P2} of the pressing device **47**. Steps S**18**, S**32**, S**33** and S**41** serve as a region specifying routine of specifying the region where the adhesive retention of the adhesive layer **10***a*. The control circuit **61** serves as a control unit and controls the pressing device **47** so that the pressing force of the contact portion **56***f* applied to the object **6** is differentiated or changed between a case where the region A**1** specified by the region specifying routine is cut and a case where the region A**2** other than the region A**1** is cut.

According to the third embodiment, the object **6** can be held both by the adhesion of the adhesive layer **10***a* of the holding sheet **10** and by the pressing force of the pressing device **47**. The region A**1** where the adhesive retention is insufficient, such as the corners of the cutting line L, is specified by the region specifying routine. When the region A**1** is to be cut, the pressing force applied to the object **6** is increased so that the pressing force is differentiated or changed from that in the cutting of the other region A**2**. As a result, the region A**1** where the adhesive retention is insufficient is pressed by the contact portion **56***f* of the pressing device **47** thereby to be held so as not be turned upward, whereupon the region A**1** can be accurately cut along the cutting line L.

The control circuit **61** serves as a speed control unit and executes the speed control routine of controlling the moving speeds of the cutter **4** and the object **6** relative to each other. The control circuit **61** is configured to differentiate or change the relative moving speed of the cutter **4** between the case where the region A**1** is cut and the case where the region A**2** other than the region A**1** is cut. According to this configuration, the moving speed of the cutter **4** relative to the object **6** can be changed according to the pressing forces F_{P1} and F_{P2} pressing the object **6**. Accordingly, when the load due to the movement of the cutter **4** relative to the object **6** is increased, the moving speed can be controlled so as to take a suitable value according to the load. Furthermore, when the load due to the movement of the cutter **4** relative to the object **6** is reduced, the relative moving speed of the cutter **4** is increased such that the cutting time can be reduced.

The control circuit **61** further serves as the region specifying unit and executes the region specifying routine of specifying the region A**1** where the angle θ made by the neighboring line segments L_{i-1} and L_i is not more than the threshold T. According to this configuration, the region A**1** including the corner of the cutting line L tends to be easily turned upward during the cutting and can be specified. Accordingly, since the specified region A**1** is pressed by the contact portion **56***f* of the pressing device **47**, the object **6** can be prevented from being turned upward, whereupon the object **6** can be cut clearly.

The foregoing embodiments are not restrictive but may be modified or expanded as follows. Although the cutting apparatus **1** is applied to the cutting plotter, the apparatus may be applied to various apparatuses with respective cutting functions. The pressing unit may be configured to move the pressing member upward and downward using another actuator such as an electric motor instead of the solenoid **57**. Furthermore, the contact portion **56***f* may be made of a material having a low frictional coefficient except for fluorine resin such as Teflon. The surface of the contact portion **56***f* (the surface in contact with the object **6**) may be coated with fluorine resin. Bright electroplating may be applied instead of the coating of fluorine resin.

The pressing device **47** may be controlled so that an amount of pressing the contact portion **56***f* applies to the object **6** is changed or differentiated between the case where the region A**1** is cut and the case where the region A**2** other than the region A**1** is cut when the object **6** is cut. More specifically, when a relatively thicker sheet such as felt serving as the object **6** is cut, corners tend to be easily rounded. In view of the problem, the processing of increasing an amount of pressing the pressing member **56** applies to the region A**1** is executed instead of the above-described step S**43**. In this case, since the pressing force of the solenoid **57** is improved, substantially the same processing as step S**43** is executed. As a result, the height of the contact portion **56***f* can be adjusted so that the thickness of the sheet is suppressed. Accordingly, each corner can be cut so as to have a clear acute angle. In the case where an amount of pressing the contact portion **56***f* applies to the object **6** is controlled, the processing may be executed so that the height of the contact portion **56***f* is slightly increased when the region A**2** is cut, instead of step S**34**.

Regarding the control unit in the first embodiment, the pressing force FP produced by drive of the solenoid **57** may be controlled so as to satisfy the expression (1). Also, regarding the control unit in the third embodiment, the pressing forces F_{P1} and F_{P2} may be controlled so as to satisfy the aforementioned expressions (2) and (3). More specifically, for example, the resultant force of the adhesion F_S and the pressing force F_{P1} may be set at the same value as the necessary holding force F_{N1}, and the resultant force of the adhesion F_S and the pressing force F_{P2} may be set at the same as the necessary holding force F_{N2}. Furthermore, the resultant force of the adhesion Fs and the pressing force F_{P1} may be set at a value exceeding the necessary holding force FN**1**, and the resultant force of the adhesion F_S and the pressing force F_{P2} may be set at the same as the necessary holding force F_{N2}.

The storage medium storing the cutting control program should not be limited to the ROM **62** of the cutting apparatus **1**. The storage medium may be CD-ROM, a flexible disc, DVD, external memory **64**, instead. In this case, data stored in the storage medium is read into the computer serving as the control unit of the cutting apparatus **1** to be executed, whereupon the same work and effect as in the above-described embodiments can be achieved.

The foregoing description and drawings are merely illustrative of the present disclosure and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the appended claims.

What is claimed is:

1. A cutting apparatus in which a cutting blade and an object to be cut are moved relative to each other based on cutting data, so that the object is cut by the cutting blade, the cutting apparatus comprising:

a holding member which is disposed at a position opposed to the cutting blade and has an adhesive layer removably holding the object;

a pressing unit which presses the object held by the holding member, the pressing unit having a contact portion which is brought into contact with the object; and a control unit which determines, in a cutting line of the object cut by the cutting blade based on the cutting data, whether an angle of a corner made by a first line segment and a second line segment adjacent to each other among a plurality of consecutive line segments constituting the cutting line is not more than a predetermined threshold, the first line segment having an end point positioned at an apex of the corner corresponding with a start point of the second line segment,

wherein the control unit controls the pressing unit so that when the object is cut by moving the cutting blade and the holding member holding the object relative to each other, at least either an amount of pressing or a pressing force of the contact portion against the object is increased in a case of cutting a portion within a predetermined distance from the apex of the corner in each of the first and second line segments compared to a case of cutting other portions in the first and second line segments if it is determined that the angle of the corner made by the first line segment and the second line segment is not more than the threshold.

2. The cutting apparatus according to claim **1**, wherein the control unit is further configured to control moving speeds of the cutting blade and the object relative to each other; and

moving speeds of the cutting blade and the object relative to each other are made slower in a case of cutting a portion within the predetermined distance from the apex of the corner in each of the first and second line segments compared to a case of cutting other portions in the first and second line segments if it is determined that the angle of the corner made by the first line segment and the second line segment is not more than the threshold.

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